POWER PLANT ENGINEERING

Established Over 35 Years

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Page

America's Largest Cleaning Establishment Operates Its Own Power Plant ... 392
Ljungstrom Turbine Fan Drives at Hell Gate. By W. E. Caldwell ... 396
Draining and Venting Extraction Heaters ... 398
13th Exposition of Chemical Industries ... 400
Floats. By J. Rowland Brown ... 401
High Pressure, Temperature and Load Factor Economy ... 404
Commercial Standards for Fuel Oils ... 404
Influence of Use on Gas and Oil Engine Design. By Harold F. Shepherd ... 405
Steam Station Economy ... 407
Design of Secondary Distribution Systems—II. By V. W. Palen ... 408
Electricity—What It Is and How It Acts. By A. W. Kramer ... 411
Standard Color Code for Control Cable. By G. Sutherland ... 413
Requirements for Refrigerating Plant Drives. By Otto Nonnenbruch and C. R. Neeson ... 415
Refractory Cement Reduces Upkeep Expense on Boiler Furnace ... 416
Compressed Air for Power Plant Uses ... 417
Design of Pipelines for Hydroelectric Plants. By John S. Carpenter ... 418
Electrical Current Distribution. By O. H. Henschel ... 420
Electric Motor Operation and Maintenance—II. By Grady H. Emerson ... 423
Electric Mule Hauls Cars. By B. T. Green ... 425
Stand for Portable Drill ... 426
Letters Direct from the Plant: Feedwater Heater Rearrangement Improves Operation. Returning a Main Bearing Journal. Windowless Construction for Paper Mill. Steam Whistle Experiences. Soft Metal Hammer. Magnetic Clutch Failure. Duplex Pumps in Elevator Service. Quickly Made Large Stamp. Pipe Racks of Scrap-Steel Sections. Defective Seals Cause Turbine Vibration ... 427
Questions and Answers: Action of Three-Valve Steam Trap. Gas Flow Through Orifice Meter ... 431
Editorial Comment: Outdoor Power Stations. Human Beings Are Still Useful. Spring Styles. Prospecting for Leaders. Multiple Effect Compressors ... 432
Test Water Cooling Coils ... 434
Heating Boiler Test with Western Coals ... 434
New Valve Uses Renewable Plate ... 435
Type SSU Pumping Units ... 435
Death of A. F. Botfield ... 436
News Notes ... 436
Books and Catalogs ... 437
Power Plant Construction News ... 438

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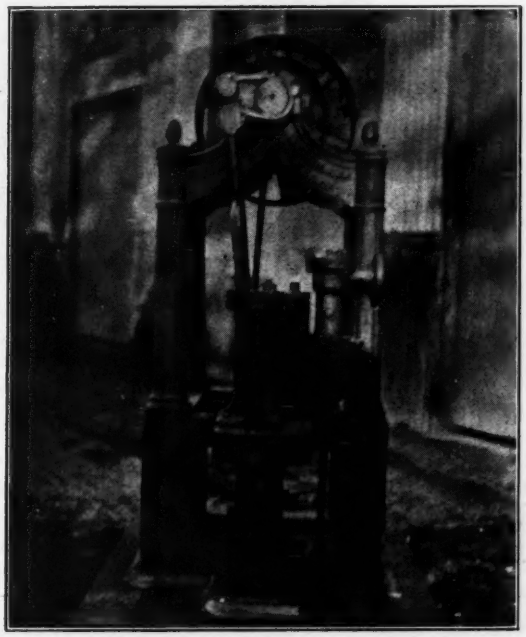


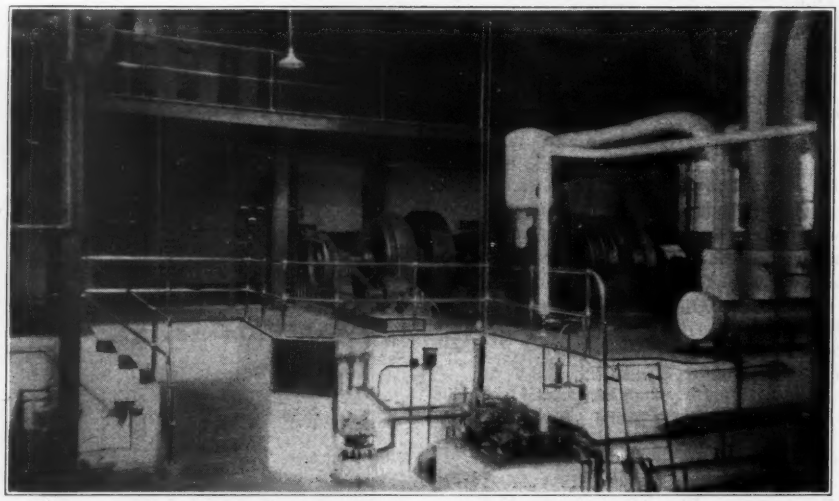
First Hundred Years are the Hardest

BALTIMORE WAS the scene of great activity one day early in the 1800's when a lumberman stopped his ox team at the town hitching post and proceeded to do some industrial shopping. He visited several small foundries and blacksmith shops and got competitive bids for castings such as a cylinder with 4⅝ in. bore and 7¾ in. stroke, four cast-iron columns, one bed plate, one flywheel, one yoke with bearing and forgings of steel for connecting rods and crank shaft.

Separate prices were asked for each piece and having secured the prices he proceeded to order each item from the lowest bidder. About a month later, he picked up the parts, loaded them on his wagon, carried them to his mill and built himself an engine technically known as a "fire engine" because power was produced by fire.

We do not vouch for the historical accuracy of all the statements above, but the lumberman who built the engine shown here will never know how well he built for within recent years this engine was sawing 4000 ft. of lumber a day in Hyde County, Virginia, and plans are now being made to give it a soft bed to the end of time in the Smithsonian Institution. It is now in possession of Surry Parker of Norfolk, Va., and the photograph is reproduced through the courtesy of F. A. Millard of the Murray Iron Works Co.

America's Largest Cleaning Establishment Operates Its Own Power Plant



DURING THE PAST YEAR, the largest cleaning and dyeing plant in America has been completed and placed in service. This plant is that of the World Cleaners and Dyers, Inc., located at Mt. Vernon, N. Y.

As a rule, until the present at least, the cleaning and dyeing industry has not been considered a large user of power, yet this new plant is large enough and the steam and electrical loads sufficiently balanced to justify the operation of its own power plant, a plant of some 500 hp. in rated boiler capacity and a total of 310 kv-a. in electric generating units. This power plant is contained in an entirely separate building apart from the cleaning and dyeing plant proper and, is provided with the most modern type of equipment.

In order to understand the need for a power plant of this size, it may be of interest first to consider briefly some aspects of the cleaning and dyeing processes and some of the general features of this particular plant.

This organization represents the consolidation of three of the foremost concerns in the metropolitan New York area, namely the Commercial Cleaning and Dyeing, the White Star Cleaning and Dyeing and the Westchester Cleaning and Dyeing companies.

Power is used in a plant of this kind for various purposes. First, of course, electricity is needed to operate the scores of motors, driving the various washers, tumblers, centrifugal dryers, fans and pumps all over the plant. In the older type of cleaning plant, it is customary to drive a number of machines from a single line shaft driven by a single large motor. This plan was followed for several reasons, first because the line shaft idea was a hang-over from early days when all industries employed line shafting and secondly, because of the danger involved in the use of motors in the cleaning rooms; the single motor as a rule was placed outside of the cleaning room proper. In the case of the World Cleaning and Dyeing Plant, this danger has been eliminated by the exclusive use of "explosion-proof" motors in all rooms where explosive gases might be present. Each machine throughout is operated by its own individual motor, controlled by new recently approved type oil switches on the machines and, also from a remote contactor board in the power plant.

Steam also is necessary for various purposes, first for drying both in the wash house and in tumbler and dye rooms, second, for heating water, third, for heating the building and finally for the operation of large numbers of pressing machines and pressing irons. Steam for the all dry cleaning equipment is furnished through a reducing valve, which reduces 150-lb. boiler pressure to 100-lb.

Exhaust steam from the engines at about 5 lb. back pressure is used for heating water and for heating the buildings. Heating of all departments of the plant is accomplished by means of unit heaters, placed near the ceilings.

This method of heating has been found to be very effective and it has many advantages, among which is the saving in floor space by the entire elimination of radiators, the more uniform distribution of heat and the ease of control. Heat is instantly available at all times and in warm weather the fans which make up part of the heater can be used for the purpose of cooling and stimulating air circulation.

With this brief discussion of the power needs of cleaning plants, we can consider better the design features of the power plant.

Since cleanliness is an essential factor in a plant of this kind, oil was selected as fuel, first because it

FIG. 1. VIEW IN POWER PLANT, LOOKING DOWN ON ENGINES, SHOWING STEAM PIPING ARRANGEMENT

meant an entire absence of dust and second because it was found that oil could be obtained at a price which compared very favorably with coal. There was also, of course, the factor of storage, which placed the balance in favor of oil for this could be stored underground.

Fuel oil is stored in underground tanks with a total capacity of 10,000 gal. This oil is pumped from the storage tanks by means of a steam pump through heaters and strainers to the four Todd, heavy duty oil burners on the furnaces.

The fuel oil pumps are automatically controlled by a Foster pump governor to maintain high and low flame.

Two boilers are installed. These are Heine type, longitudinal drum units, rated at 255-hp. each, operating at 150 lb. pressure and made by the Combustion Engineering Co. These boilers are set in battery about ten feet above the floor. The furnace is constructed with a 13-in. fire brick lining throughout. An interesting feature is the furnace floor; this consists of 8 in. of hollow tile, 5 in. of Silocel insulating brick, over which is placed 9 in. of fire brick.

This construction has resulted in a distinct saving in fuel. At night, the plant of course shuts down and the fires are extinguished. Previous to closing time, however, the water level in the boilers is permitted to drop and when the fires are removed, the boiler is filled with cold water and all drafts closed. Under these conditions, the water in the boiler absorbs enough heat from the brick refractory so that in the morning there is practically full steam pressure on the boilers.

If this scheme of operation were not followed the boilers would blow off some 15 or 20 times a night.

The oil burning system is shown in Fig. 4. As will be noted, the piping forms a closed loop, the oil circulating continuously so as to maintain a constant high temperature at the burners. It will be noted also that there are both steam and electric heaters and pumps. These are provided for starting up on Monday mornings or at any other time after the plant has been shut down. A connection is maintained with the local public service company so current is always available for this purpose.

The electric heaters are of the immersion type, one rated at 5000 w. and the other at 10,000 w. The smaller unit is placed on the suction side of the fuel pumps to aid in pumping when the oil is cold. The steam heater is a coil type heater which was made up at the plant. The steam heater is rated to heat 500 lb. of oil per hour from 60 to 200 deg.

The control of the steam-driven oil pumps is of interest, as it is accomplished through the agency of two pump governors, one controlling low fire and the other controlling maximum fire. These pump governors are set to operate at different steam pressures. Ordinarily the temperature of the oil is maintained at 200 deg. and the pressure varies between 100 and 200 lb. depending upon load conditions.

Electric Generating Equipment

Two electric generating units are provided, one a Skinner Universal Unaflow engine, direct connected to a 185-kv-a., 240-v., 3-phase, 60-cycle, Crocker-Wheeler generator, the other a Skinner counterflow engine driving a 125-kv-a. generator of the same voltage and make. Both generators are provided with individual belted exciters.

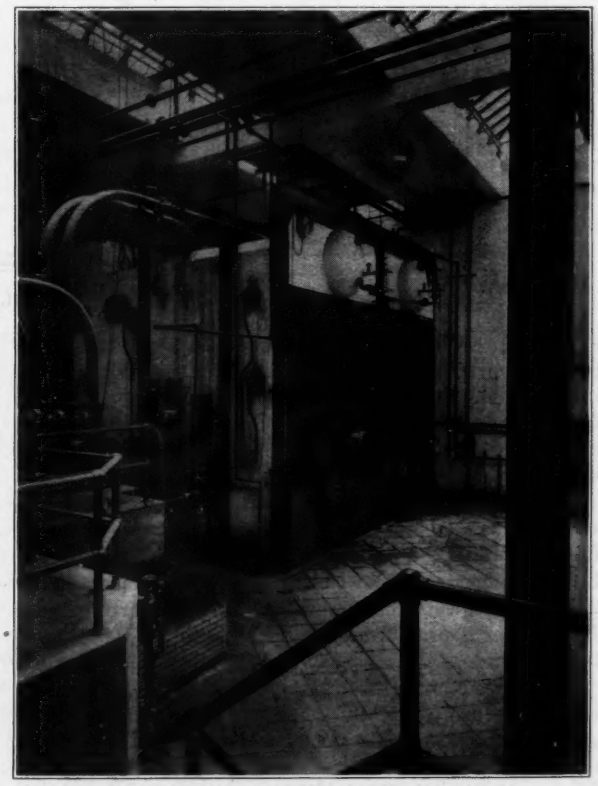


FIG. 2. GENERAL VIEW IN BOILER ROOM

These engines operate on a steam pressure of 150 lb. and exhaust against a back pressure of 5 lb. which, as already stated, is used for water heating and heating of the buildings.

The piping arrangement is quite simple. The headers from each boiler feed into a header placed on a level just a few feet above the engine room where the valves are easily accessible. This is shown in Fig. 1. All steam distribution, both to the engines and to the cleaning plant is from this header.

The plant is well equipped with instruments and meters. On a panel board near the boilers are mounted 2 boiler pressure gages, 1 reduced pressure gage on the line to the laundry equipment, a fuel oil pressure gage, a water pressure gage and a gage showing the back pressure on the heating system. In addition to these instruments there is a Liquidometer measuring device for determining the height of the oil in the storage tank and recording thermometers for stack temperature, hot water and fuel oil temperatures.

The boilers are equipped with the following accessories: Yarway tandem blow off valves, two per boiler, Reliance water columns with high and low level alarms, Lunkenheimer stop and check valves and safety valves. All other valves in the power plant are Walworth valves. Each boiler is provided with five elements of Bayer soot blowers.

No forced or induced draft fans are provided but the boilers are served by a 105-ft. Kellogg radial brick smokestack. With this stack and with the oil burning equipment available, there is no difficulty experienced in operating the boilers at 200 per cent rating.

An interesting feature in connection with boiler operation is the fact that four different means of boiler feeding are possible. First, there is the normal method, which is used under all ordinary conditions and which makes use of a large Morehead trap located above the boiler.

Second, a boiler feed pump is provided which can be used if the trap should not be in operation.

A third method is available because of the high city water pressure available, i.e., 120 lb. per sq. in. When the steam pressure falls below 120 lb., which is quite frequently the case when running the small engine, the boilers may be fed direct from the city water lines.

A fourth method involves the use of an injector.

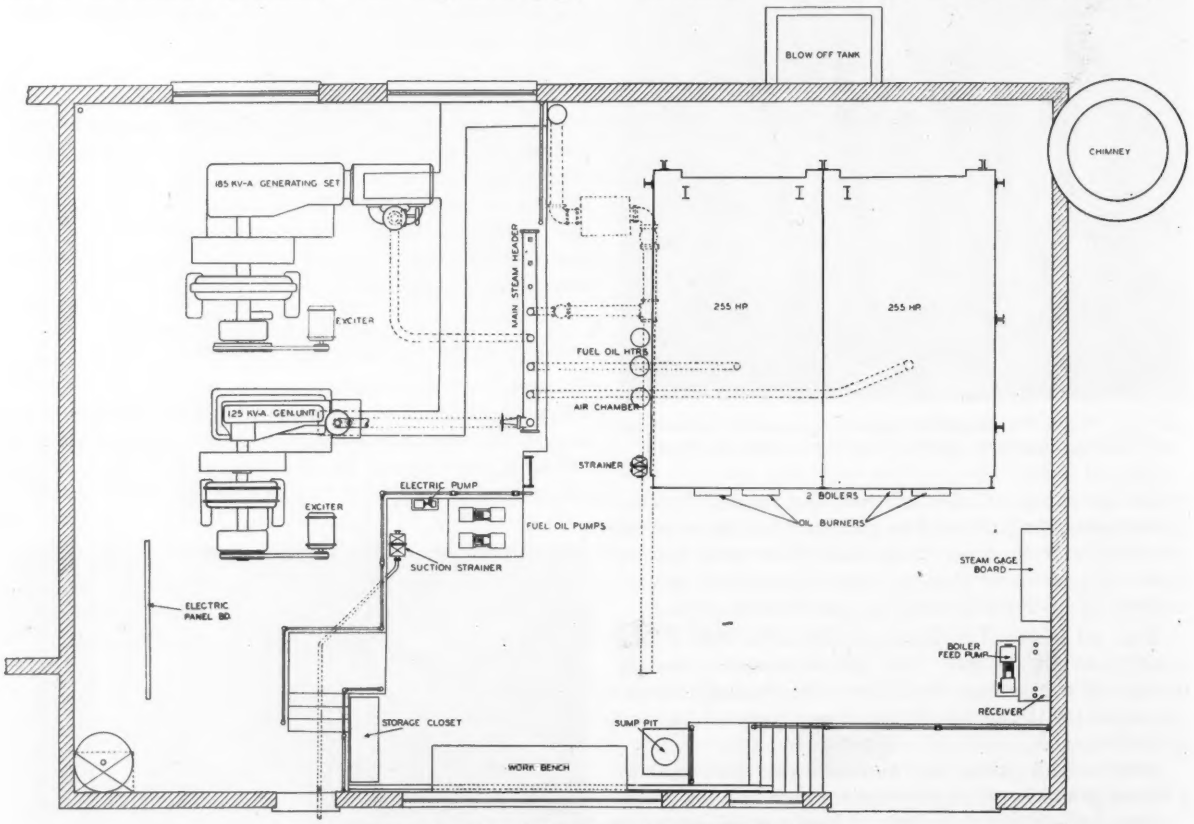


FIG. 3. LAYOUT OF BOILER AND ENGINE ROOM

The system of condensate returns is well worked out —nearly all condensation being returned to the boiler automatically. No traps are installed on any individual steam consuming equipment. The condensate returns from the individual equipment is provided for through a swing check valve, the return being run to a high or low-pressure receiver.

A simple diagram of the boiler feed shown in Fig. 5. The boiler feed pump can pump either from the hot-water heater or receiver as desired by opening and closing valves as shown.

Hot water, not only for general service but for boiler feed, is provided by a Patterson-Kelley closed heater, controlled by a Fulton sylphon regulator. This regulator is set to maintain a constant high temperature of about 200 deg. F.

All current used by the motors in the plant is generated and distributed at a potential of 240 v. This

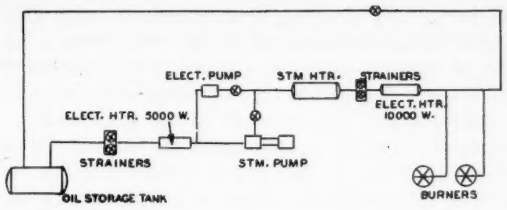


FIG. 4. ARRANGEMENT OF OIL BURNING SYSTEM

voltage is maintained constant by an American Brown Boveri regulator. The normal load on the plant is some 400 amp. The generator capacity is supplemented by a 20-kw. breakdown service supplied by the local public service company.

Generator leads pass directly to generator panels from which leads pass to the main distribution and control panel located on the balcony. This control board is of interest since it contains all the switches and fuses as well as certain automatic contactor equipment for the motors throughout the plant. It is equipped throughout with Square D switches and was constructed by the Industrial Controller Co. The total length of the board is over 70 ft. but it is arranged as two 35-ft. panels placed back to back. Features of this board are staggered control of the reversing switches of all motors on the tumblers and washers, whereby these machines go into reverse at different intervals of time. This reduces the load fluctuations considerably.

All relays and reversing drums are encased in dust proof cases to protect them against impairment by dust and foreign matter.

Fuses and switches are mounted on this board instead of on the machines themselves, not only to remove the danger of explosion in rooms where explosive gases might be present but also to centralize the entire control at the power plant.

All wiring from this panel board to the various machines is run in lead covered conduit underground.

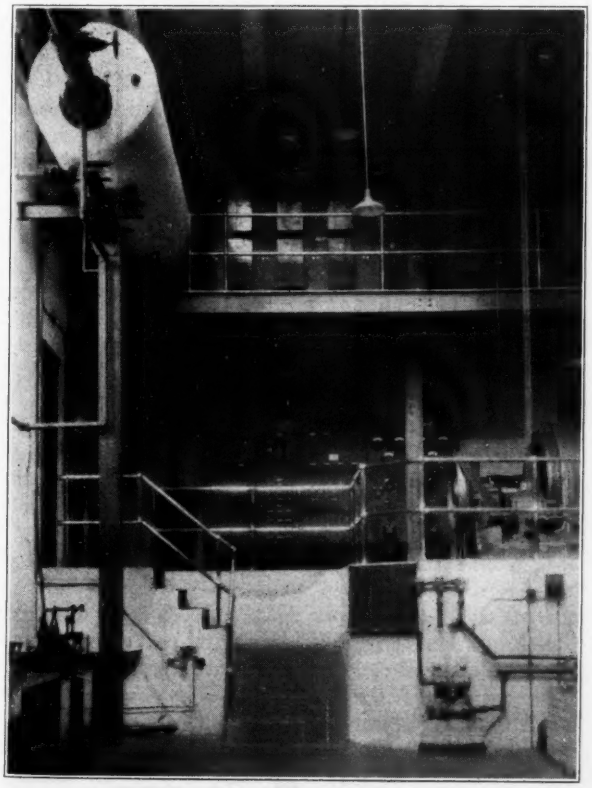


FIG. 6. A VIEW FROM THE BOILER ROOM FLOOR, LOOKING UP AT THE DISTRIBUTION BOARD AND THE WATER HEATER

Conclusion

Taken as a whole, this is a well designed small plant,

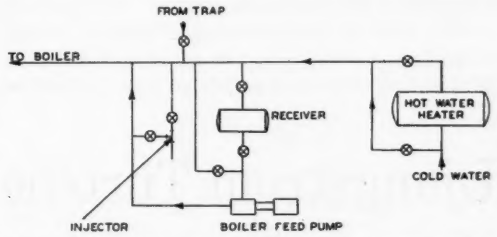


FIG. 5. DIAGRAM SHOWING FEEDWATER SYSTEM

adequate to take care of all the needs of the institution which it serves and designed so as to produce steam and electricity at an attractive rate. The average cost of

PRINCIPAL EQUIPMENT IN THE WORLD CLEANERS AND DYERS POWER PLANT

Boilers: 2 longitudinal drum, 255-hp. Heine type water tube boilers .....Combustion Engineering Corp.
Furnace Construction: 13-in. firebrick lining throughout. Floor 8-in. hollow tile, 5-in. Sil-O-Cel insulating brick; 9-in. firebrick. Sil-O-Cel blocks by Johns-Manville.
Fuel Oil Burners: 2 per boiler, high-pressure mechanical type .....Todd Shipyards Corporation
Fuel Oil Pumps: 2—4½ by 2 by 2-in. Duplex steam pumps .....Warren Steam Pump Co.
1 Electric Oil Pump: Kraissel gear type, driven by 3-hp. electric motor.
Fuel Oil Heaters: 2 Atlas coil type, steam heaters.....Breuer Engineering Co.
2 electric immersion type heaters of 5000 and 10,000-watt capacity.
Boiler Feed Pump: 1—6 by 4 by 6-in. duplex pump, Warren Steam Pump Co. equipped with Mason excess pressure regulator and Patterson-Kelley receiver.
Traps: 3 No. 5 Morehead traps, 2 for direct boiler feed and 1 low-pressure lift trap.....Morehead Mfg. Co.
Oil Pump Regulator: Foster governor.Foster Engineering Co.
Boiler Accessories:
Blowoff valves—Yarway tandem, 2 per boiler.....Yarnall-Waring Co.
Water columns—Reliance, high and low level alarm.....Reliance Gauge Column Co.
Soot blowers—5 units per boiler.....Bayer Co.
Valves on boiler including safety valves.Lunkenheimer Co.
Valves in Plant.....Walworth Co.
Hot-Water Heater—Closed type.....Patterson-Kelley Co.
Oil Separator .....Morehead Mfg. Co.
Injector .....Ohio Injector Co.
Generating Units: 1 Skinner universal unaflow, non-condensing engine direct connected to a 185-kv-a. Crocker-Wheeler 240-v., 3-phase, 60-cycle generator.
1 Skinner counterflow, noncondensing engine, direct connected to a 125-kv-a. Crocker-Wheeler, 240-v., 3-phase, 60-cycle generator.
Electric Distribution Board.....Industrial Controller Co.
Voltage Regulator.....American Brown Boveri Co.
Electric Motors in Plant.....Louis Allis Co.
Boiler Panel Gage.....Foxboro Co., Republic Flowmeters Co., Bristol Co.
Oil Gage .....Liquidometer Corporation
Oil and Water Meters—Niagara.....Buffalo Meter Co.

current, not taking into account the value of the exhaust steam, is 1 1/5 cents per kw-hr.

By means of the two generating units, economy of operation can be maintained under varying load conditions. In summer time when the plant load is heaviest and when the use for exhaust steam is limited to heating water for dyeing, wet cleaning and other minor uses, the 105-kw. Unaflow engine is used. This engine has a better water rate than the smaller unit. In winter, however, the counterflow engine is used for then the electrical load is light and the demand for exhaust steam greater because of the necessity for heating the buildings.

This plant is the largest of its kind and no doubt the most modern. The electrical features are particularly noteworthy and the centralization of electric control for the cleaning machinery is a distinct step in advance. As has been stated, there is a switch on each piece of equipment in the dry cleaning departments so as to give the operator immediate control of the equipment. In the event of trouble, however, requiring the current to be cut off, there is direct means of communication between the operator and the engineer in the power plant who disconnects any such equipment at the main panel board. The switches on the panel board bear numbers corresponding to the number plates on the equipment so that instructions in this respect can be followed with no loss of time.

In conclusion, acknowledgment is made for courtesies extended in the preparation of this article, to the Management of the World Cleaners and Dyers, and to Nelson M. Breuer of the Breuer Engineering Co. of New York under whose direction all power plant equipment was installed. The plant was designed by Irving M. Fenichel, architect.

Ljungstrom Turbine Fan Drives at Hell Gate

TANDEM-COMPOUND TURBINES DRIVE FORCED AND INDUCED DRAFT FANS IN HELL GATE EXTENSION. BY W. E. CALDWELL*

AMONG THE NEW and unusual features in connection with the latest boiler installation at Hell Gate are the turbine drives for the forced and induced draft fans. In the selection of turbines, steam consumption was an important consideration and studies of turbine water rates indicated that high-speed turbines would be necessary to secure the efficiency exacted by economic considerations. Compound turbines were finally selected as the most satisfactory drive arrangement consistent with economy at moderate speeds.

Four induced draft fans, each of 125,000 c.f.m. at 17 in. static pressure, and two forced draft fans, each of 150,000 c.f.m. at 11.5 in. static pressure, are installed for each boiler. The induced draft fans are operated in pairs, each pair having a common shaft, driven through a reduction gear by a 974-hp., high-pressure turbine operating at 7500 r.p.m. maximum. The forced draft fans are operated singly and are driven through a reduction gear by a 393-hp., low-pressure turbine operating at 6000 r.p.m. maximum. The low-pressure turbine exhausts into a closed heater against a back pressure of from about 5 to 25 lb. gage depending upon the boiler load.

There are two compound turbines per boiler for the fan drives, and although the receiver lines of each set are interconnected, each set is normally operated as a unit by keeping the sectionalizing valve in the cross over piping closed. By opening this sectionalizing valve, one forced draft turbine may be operated with two induced draft turbines, or two forced draft turbines operated with one induced draft turbine. This arrangement provides more flexibility than would be possible with independent turbines for each fan. With one-half of the fans out of service, the boiler may be operated up to about 75 per cent capacity.

Total steam passing through the high and low-pressure turbines is controlled by six cam operated poppet valves, which admit steam to the six groups of admission nozzles in the high-pressure turbines. Control and distribution of load between the high and low-pressure turbines is accomplished by means of multinozzle control on each turbine. In addition to the nozzle control, each

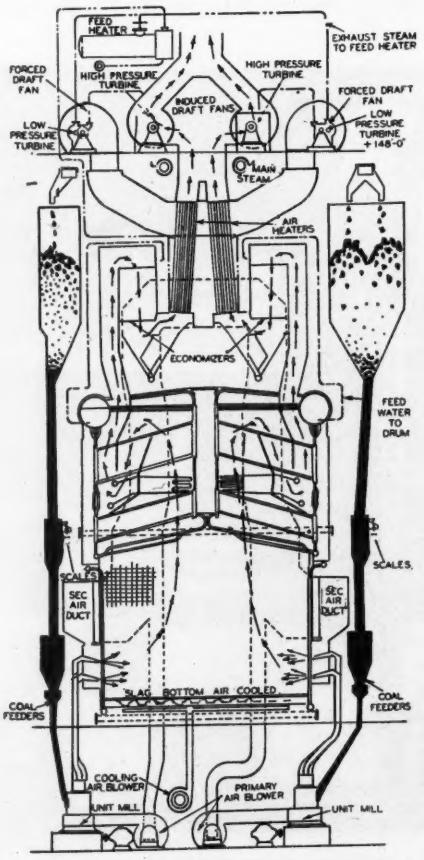


FIG. 1. CROSS SECTION SHOWING THE ASSEMBLY OF THE NEW NO. 91 AND 92 BOILERS AT HELL GATE

*United Electric Light & Power Co., New York, N. Y.

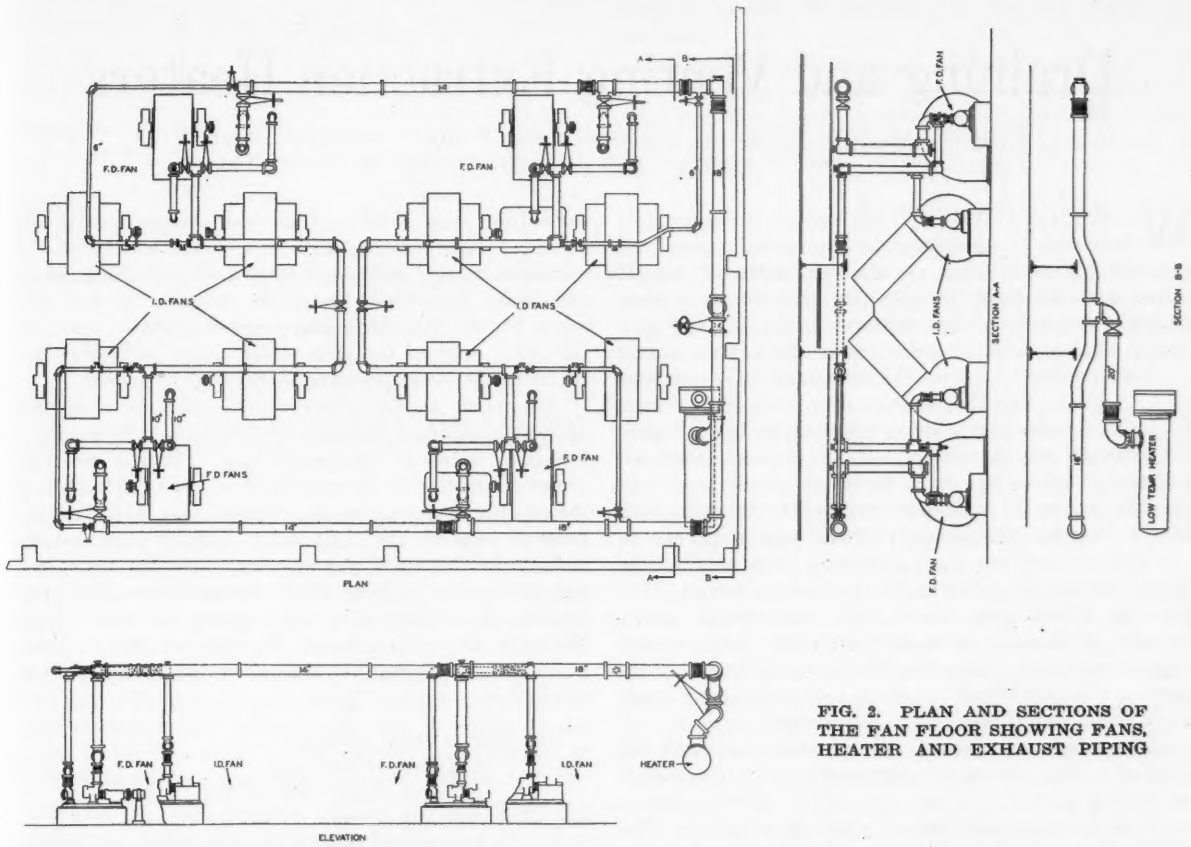


FIG. 2. PLAN AND SECTIONS OF THE FAN FLOOR SHOWING FANS, HEATER AND EXHAUST PIPING

turbine is provided with a throttling governor operating an independent valve as well as with an overspeed trip.

One-third of the total nozzle inlet area of the low-pressure turbine is controllable through six poppet valves operated by cams. By closing off some of the admission area of the low-pressure turbine nozzles, the receiver pressure is raised. In this way the available heat drop is decreased for the high-pressure turbine and increased for the low-pressure turbine, providing means for equalizing of the work between the units to suit the operating conditions.

Turbines, which were made by the B. F. Sturtevant Co., are of the Ljungstrom axial flow type, having a Rateau element at the inlet followed by several stages of reaction blading. The rotors are solid forgings and operate below their critical speed. Due to the very limited space available, the small size of the turbines, made possible by the relatively high speed, renders them particularly attractive for this installation.

Reduction gears have undercut teeth to provide sufficient elasticity and uniform distribution of tooth pressures. To provide flexibility between the turbine and pinion a quill drive is used; that is, a flexible driving shaft from the turbine extends through the hollow pinion shaft and connects at the remote end to a flexible metallic disc.

A feedwater heater which receives the exhaust steam from these fans is located on the fan floor, the feedwater passing through it and on to the economizers. This arrangement permits the use of a simple and compact exhaust piping layout. As the boiler is provided with an air heater beyond the economizer, the larger part of the flue gas loss, resulting from the elevation in feedwater temperature due to this arrangement, is recovered by the air. The condensate from this heater is delivered by a pump into the feed line beyond the heater discharge.

RECENTLY the Hudson County, N. J., Board of Health and Vital Statistics passed a smoke abatement ordinance creating a department of smoke regulation under the direction of William G. Christy, Smoke Abatement Engineer.

Production or emission of smoke, flyash or fumes, the shade of which is equal to or greater than No. 3 of the Ringlemann Chart or which is so dense as to prevent seeing through it at the point of emission into the external air, for periods aggregating 2 min. or more in a period of 15 min.; or the emission of No. 2 smoke dense enough to be dimly seen through it at the point of emission, for a period or periods aggregating 12 min. in any hour, constitute a violation of the ordinance punishable by a $50 fine or a 30-day jail sentence or both. With steamboats and locomotives, the corresponding periods are 30 sec. out of 3 min. for No. 3 smoke and 4 min. out of 15 for No. 2 smoke.

WITH THE INCREASING power consumption of boiler auxiliaries, more care is being given to the design of gas and air ducts and breechings. Entrance losses from improperly formed inlets, discharge losses from poor transitions and eddy losses from angular turns, can all be reduced by proper design.

Draining and Venting Extraction Heaters

METHODS VARY WITH EQUIPMENT AND FUEL COSTS; HIGHEST EFFICIENCY OBTAINED WHEN DRAINS ARE PUMPED TO THE DISCHARGE SIDE OF EACH HEATER

WITH THE ADVENT of the extraction heater, new problems in equipment arrangement, piping and heat balance layout arose. Instead of a relatively simple layout with the hotwell pump pumping the condensate from the hotwell through the air ejector, oil and generator air coolers to an open heater, the piping is now invariably complicated by the introduction of one, two or even more extraction heaters preceding and perhaps one or more extraction heaters following the open heater.

In effect, the extraction heater is a small dead end condenser operating at some pressure between the throttle and main condenser pressure. As such, each heater must be arranged so that the condensate can be drained out and the noncondensable gases and vapors vented so that the tubes do not become air bound. The problem differs from the hotwell and vacuum pump problem of the main condenser only in the pressure conditions and in the quantities handled and is exactly the same as the problem of draining and venting the steam jet vacuum pump inter and after coolers.

Drain and vent methods actually used vary with the type of turbine, steam pressure and cost of fuel so that no typical method can be given either for the practice of the industry as a whole or for any one company. The highest thermal efficiency is obtained when the condensate or drain is pumped back into the main condensate flow on the discharge side of each heater. This method avoids any degradation of heat head, a factor which must be considered of equal importance with B.t.u. recovery in high-pressure plants. Such an arrangement calls for a drain pump with each heater, however, and this cannot be justified except in the case of large stations using relatively expensive fuel because these drain pumps are small and the service severe so that their efficiency is low.

The simplest method is to drain each heater direct to the condenser, either through a trap or gooseneck water seal. Obviously this is the simplest but at the same time most inefficient method because practically all the heat of the liquid is lost to the condenser. A variation of this method is known as cascading, where the drains from each heater are cascaded to the next lower heater, through a trap, orifice or water seal. In this way, some of the heat of the liquid is flashed into steam in the lower-pressure heater and recovered.

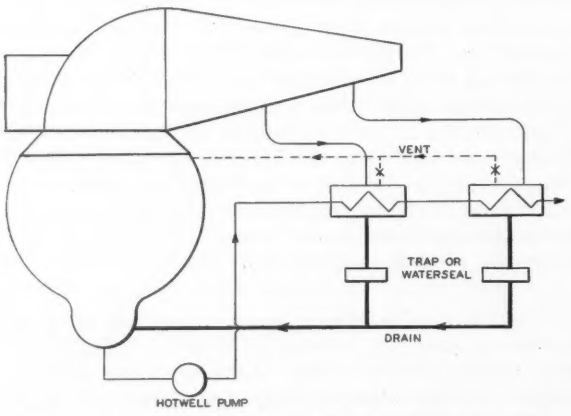


FIG. 1. BOTH HEATERS DRAINED DIRECT TO THE CONDENSER

Inasmuch as this flash vapor displaces a certain amount of extracted steam, the increase in economy is less than indicated on the surface. Perhaps the most common practice at the present time is a combination of the cascade and drain pump method; that is, the higher-pressure heaters are cascaded to a lower one and the combined drains are pumped back into the main condensate flow at a point which depends upon local conditions. Thermally, it is best to pump the drain to the discharge of the heater and this is almost always done.

In outline form, the various methods can be summarized as:

I. Heater drain methods
  1. Direct to condenser
    A. Water seal or loop
    B. Trap
  2. Cascade to next lower heater
    A. Water seal
    B. Trap
    C. Orifice
  3. Pump to main condensate line
    A. Discharge of heater
    B. Inlet of heater
    C. To special pumps
  4. Combinations
    A. 1 and 2
    B. 2 and 3

II. Air vents from heaters
  1. To condenser
    A. Direct
    B. Through vent condenser
  2. Cascade to next lower heater
    A. Draft
    B. Through vent condenser
  3. To lower stage of turbine

It is obvious that the first method of the outline, indicated by Fig. 1, i.e., draining the heater direct to the condenser, would, with more than one heater, be practiced only as an emergency method. It is not only more efficient but also simpler to cascade the drains from the higher pressure to the next lower pressure heater, as shown by Fig. 2. When the pressure difference between heaters, or between the last heater and the condenser, is small enough so that the seal can be made with a reasonable gooseneck loop, this is the best method to use.

With high pressures, a trap or discharger is preferable. These traps should have a large continuous flow capacity and some engineers insist that they have suf-

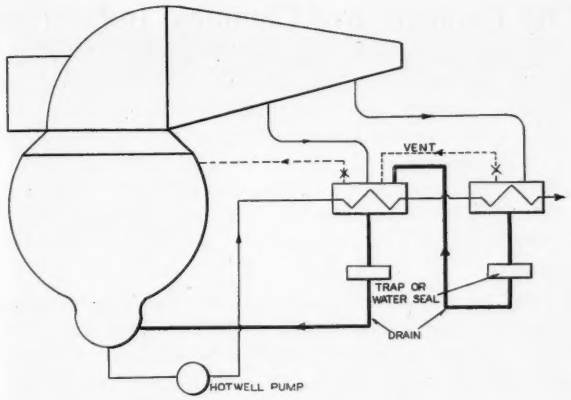


FIG. 2. DRAINS AND AIR VENTS CASCADED TO THE NEXT LOWER HEATER AND THEN TO THE CONDENSER (COMMON PRACTICE)

ficient excess capacity to take care of a broken heater tube without flooding the heater. In the past, a fixed orifice was sometimes used in the drain line but this is seldom used now except in small plants because of the loss of steam at low loads. The orifice is made large enough to handle the flow at maximum load. As the load drops off, however, there is not sufficient water to keep the orifice sealed and a small amount of steam will blow through. The loss in this case is equal to the power which this steam would generate if expanded in the turbine between the upper and lower bleeder points.

When the high-pressure drains are cascaded, the cumulative drains from the last heater can be taken direct to the condenser, as in Fig. 2, or pumped into the main condensate line, as in Fig. 3. In order to utilize the heat head of the drains, they should be pumped back to the discharge or high temperature side of the heater as shown. This also gives a lower pump discharge pressure by the amount of the condensate pressure drop through the heater. Local conditions may make it advisable to pump the drains to some other part of the system, however. For instance, in one plant the drains are pumped to the suction of the boiler feed pumps and in another to an intermediate stage of the feed pump, the decreased pumping head in each case being of greater importance than the few degrees of heat head.

Draining each heater by a separate pump, as in Fig. 4, is theoretically the most efficient but the capital expense and low operating efficiency of the drain pumps makes this method extremely expensive and seldom, if ever, justified.

Venting

Venting the air and noncondensable gases from these heaters is extremely important if their heating efficiency is to be maintained. Practice in this connection varies widely but as the heat content of these vapors is not as great as that of the drains, heat recovery is not as important. The simplest method is to connect the vent from each heater to a common line or manifold connected to the steam space of the condenser, as shown by the dotted lines in Fig. 1. Another method is to cascade them from heater to heater, as shown by the dotted line of Fig. 2 while still a third method is to vent each heater to a lower stage of the turbine as shown by the dotted lines of Fig. 3.

Some companies use a fixed orifice in the vent lines, others use a needle valve to give close control and still others use an ordinary globe valve so that they can be opened up wide for quick starting and then throttled by hand until the valve is just cracked so as to vent just enough to keep the heater free of air. The operator can tell when an excess amount of steam is passing by the temperature of the vent line.

Open Extraction Heaters

Vent condensers are not commonly used with closed heaters but are common practice with open heaters which are usually vented to the atmosphere. In two recent central stations open heaters are used exclusively for extraction service and in each case individual vent condensers are used. Figure 5 illustrates the application of these vent heaters to two types of open heaters; the first a jet heater and the second or high-pressure one, a rain type. With open heaters, the drain problem is eliminated because the condensed steam is mixed with the main condensate flow. Each heater, however, requires a separate pump large enough to handle the complete flow. So far these pumps have been combined into single units similar to the usual multistage centrifugal.

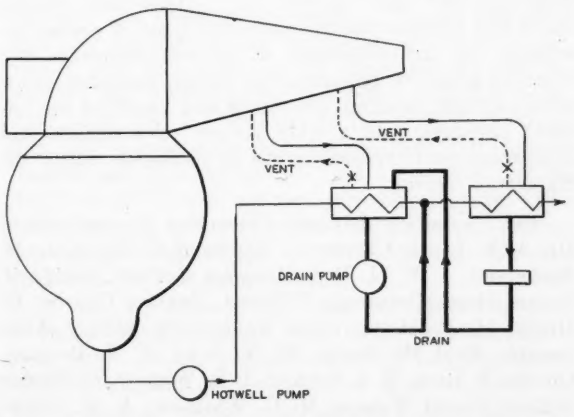


FIG. 3. DRAINS CASCADED TO THE LOWER HEATER AND PUMPED BACK TO THE HEATER DISCHARGE (COMMON PRACTICE). VENTS TAKEN TO A LOWER STAGE OF THE TURBINE

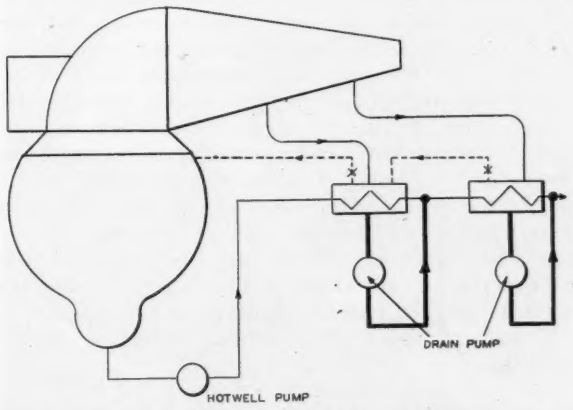


FIG. 4. DRAINS FROM EACH HEATER PUMPED BACK TO THE DISCHARGE

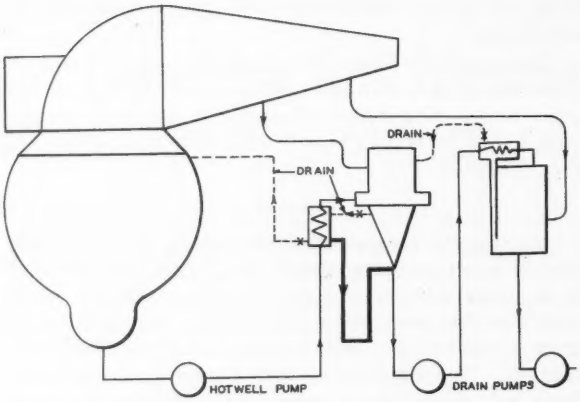


FIG. 5. VENT HEATER ARRANGEMENT WITH TWO TYPES OF OPEN EXTRACTION HEATERS

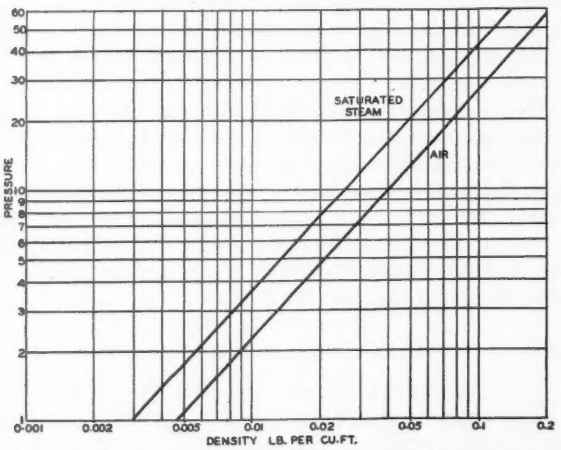


FIG. 6. AIR IS MORE DENSE THAN STEAM AND WILL COLLECT IN THE LOWER PART OF THE HEATER

When venting heaters, it must be remembered that, as shown by the curves in Fig. 6, air is more dense than steam and unless carried along by sufficient steam or water flow will tend to collect and blanket the lower part of the heater. In most cases, vent lines must be taken from the lower portion of the shell.

BELT DRIVES can be used to advantage in many places but they should never be put in without considering all the factors such as, type, speed, width, tension and life of the belt, size and surface of pulleys and construction of the bearing. Small pulleys shorten the life of belts, narrow belts are apt to slip, which is a big factor in belt deterioration. Small pulleys and narrow belts also require excessive belt tension which puts a strain on shafts, pulleys, belts and bearings. Overhung pulleys should be used only for small powers and with light belts. Shafts and bearings should be lined up properly and well supported. With heavy belts transmitting considerable amount of power, it is well to support the driving shaft on separate bearings and connect it to the shaft of the driven machine through a flexible coupling.

BRASS PIPE should always be used for alum lines on water treaters.

13th Exposition of Chemical Industries

DURING THE WEEK of May 4 to 9 inclusive, 1931, the Thirteenth Exposition of Chemical Industries will be held at the Grand Central Palace, New York. It has already been announced that the Student's Course upon the Fundamentals of Chemistry and Chemical Engineering will again be instituted under the chairmanship of Prof. W. T. Read, Dean of Chemistry at Rutgers University, who is a member of the Exposition Advisory Committee.

The exposition will include three floors of exhibits devoted to the raw materials suitable for the manufacture of chemicals and chemical products, various other technical products used in the arts and industries, apparatus and equipment, machinery and the finished products of the chemical industries.

Machinery and apparatus will vary from laboratory equipment, supplies and instruments through instruments of precision for recording temperature, pressure, volume, flow and the many other factors which are brought under control in industrial operations, through the apparatus and equipment in large scale operations, and in many cases whole processes will be shown in operation.

Special fundamental operations utilized in the chemical industries will be shown in the demonstrations including distintegration, crushing, grinding, grading, mechanical separation, including filtration, classification, settling, thickening, evaporation, distillation, drying, weighing, measuring, mechanical handling of materials, conveying, the demonstration of materials of construction, and in this the chemical industries are constantly seeking materials for permanence to resist corrosion and destruction by the materials used in reactions conducted in the industries; and the products displayed will include ceramic materials, glassware, metals, alloys, plastics, wood, fibers, fabrics and a long list of materials developed for many special purposes.

There will be special sections in the Exposition devoted to the showing of the raw materials from our Southern States, a section for the Natural Resources of Canada and its various Provinces, a section for Laboratory Supplies and Equipment, another for Materials Handling and still another for a Container section which will demonstrate the numerous types of containers suitable for the containing of various chemicals and chemical products, apparatus for filling, weighing, measuring, sealing, labeling, packaging and handling the finished packages, and a wide variety of materials and equipment used throughout the 94 industries which the Exposition serves.

The Exposition Advisory Committee is comprised of Dr. A. D. Little, Chairman; Raymond F. Bacon, L. H. Baekeland, J. V. N. Dorr, Lammot duPont, Henry B. Faber, Moses Gomberg, Williams Haynes, Charles H. Herty, H. E. Howe, Louis Kahlenberg, Sidney Kirkpatrick, Fred W. Payne, W. T. Read, L. V. Redman, Charles F. Roth, H. J. Schnell, T. B. Wagner, R. Gordon Walker, David Wesson, M. C. Whitaker, A. H. White, Victor Williams, and is under the direction of the International Exposition Company with offices in Grand Central Palace, New York, Charles F. Roth, Manager.

FLOATS

Evolution of Their Manufacture From a Wood Block to Seamless Monel Metal

By J. Rowland Brown*

EXTENT of their use and the dependence we place on floats is evidenced by the fact that at least 50,000,000 floats are in actual use in the United States today, in automobiles, toilet tanks, electric refrigerators and thousands of other devices. In this article, however, we shall consider only floats that are used in the heating and power field, subjected to heat and pressure while immersed in a liquid.

First Steps

Oldest of types of float is a solid block of wood, cork or other substance lighter than the liquid; but they all have short life when subjected to pressure and especially under steam temperatures.

Next in development was a solid metal float heavier than the liquid but counterbalanced by a weight above the surface. Solid counterbalanced weights as floats introduced too much friction, due to excessive weight and the necessity of leveling the mechanism, hence are seldom used where dependable and accurate performance is necessary.

Obviously the thing to do was to make a hollow body of some non-corrodible metal but at first few metals were available and manufacturing processes were undeveloped. Sheet copper offered the best material for working and for resisting corrosion so the earliest metal floats for pressure service were made by spinning sheet copper into cups, beading the edges, placing the cups together and then spinning the beaded edges down to a tight joint, Fig. 2. This gave a fair float for low pressure and temperature but temperature and pressure changes soon opened up the joint and caused leakage. Reënforcing rings under the seam helped some. Then floats were made with the joint soldered but, although better than the spun type of joint, solder does not stand up alone under repeated stress.

A real step forward was made with the introduction of the so-called seamless float, which was seamless in name only. It was generally made of two copper cups soldered together, sometimes over a reënforcing ring with a shell of copper electrodeposited over the entire float, making it seamless on the outside. Since much of its strength depended on the inside soldered cups, in time the inside joint would fail and the outside deposited shell, not being able to carry the load alone, would rupture.

Float failure is due to collapse under pressure or to leakage. A float must be kept light in order to have buoyancy and, as pressures went higher, it soon became difficult to make a float with sufficient strength to prevent collapse, yet light enough to have needed buoyancy.

More Strength Needed

Reënforcing rings were placed under the joint to give added strength but soon even this failed. Someone hit upon the scheme of injecting a measured amount of water into the float so that the heat from the steam surrounding the float would cause the water to evaporate

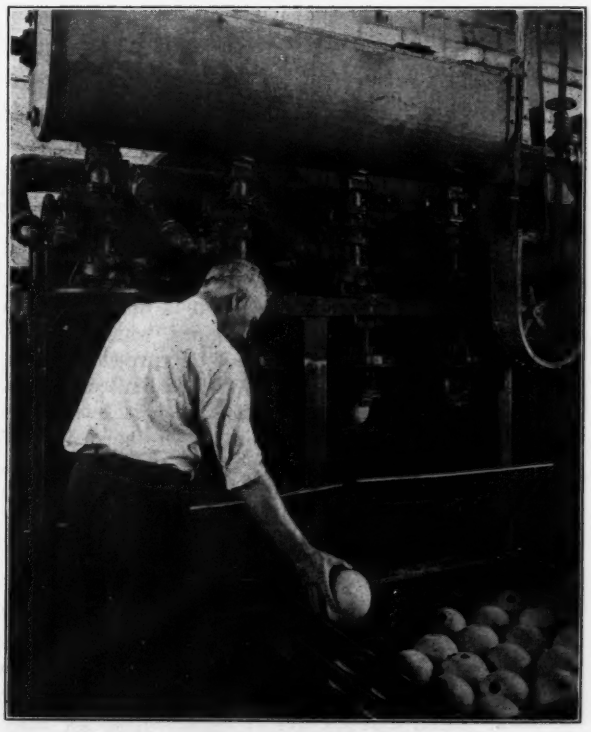


FIG. 1. MAKING THE MACHE FORMS

*Reliance Gauge Column Co., Cleveland, Ohio.

and generate pressure inside, somewhat below the external pressure but close enough nearly to counteract it. Soon it developed that users buying new floats would shake them and hearing the water inside reject them as leakers. To overcome this, one manufacturer put a small quantity of absorbent cotton inside with the water and, as the water was absorbed, it could not be heard when shaking the float.

One inventor took out a patent on the use of a liquid more volatile than water, inside the float and, by choosing the correct liquid, could create a pressure inside even greater than the external. But for a boiler or an accessory attached to a boiler, any volatile liquid inside a float to counteract pressure was useless because a boiler and its accessories are subjected to a cold water test from 50 to 100 per cent above the maximum working pressure. This would be the greatest pressure the float would be called upon to withstand yet, because it was cold, the liquid inside would not evaporate.

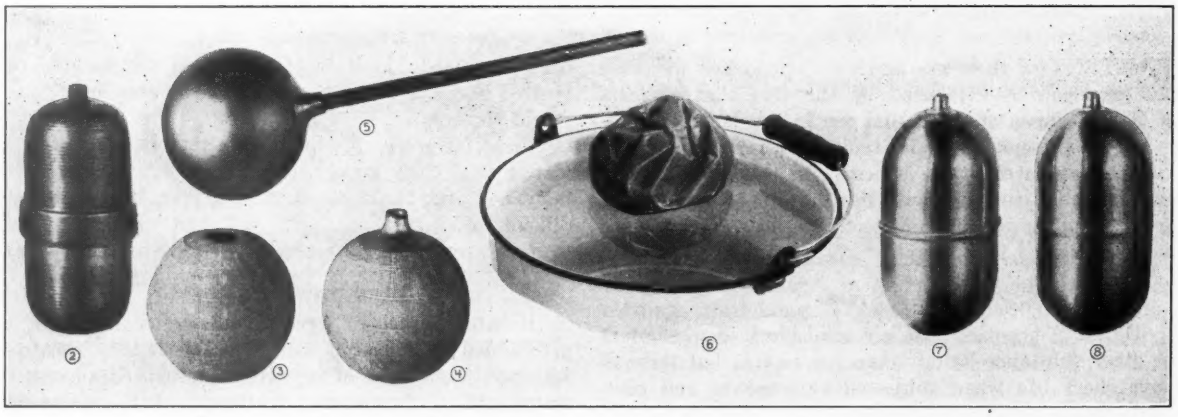


FIG. 2. TWO-PART FLOAT WITH SPUN JOINT FIG. 3. FORM FOR SEAMLESS FLOAT FIG. 4. FLOAT FORM WITH SPUD ATTACHED FIG. 5. FORM WITH STEM READY FOR ELECTRO-DEPOSITION FIG. 6. FLOATS DO NOT LEAK EVEN WHEN CRUSHED FIG. 7. LONG FLOATS ARE MADE FROM TWO CUPS WITH EDGES FUSED TOGETHER FIG. 8. COMPLETED FUSED-CUP FLOAT

High Temperature Effects

As pressures went up, temperatures also rose. For trap floats used on superheated steam lines, two factors began to give trouble. The highest-melting-point solder that has any strength and workability melts at about 500 deg. F. and at some point between 400 and 450 deg. is weakened so that an excessive strain is thrown on the electrodeposited outside shell. Copper, which had become the almost universal metal for pressure floats, anneals soft around 500 deg. F., while a limited amount of softening or anneal takes place when it remains in steam at 450 deg. for a long time. The hardening of copper by spinning or pressing was used to give floats greater resistance to collapse but, when temperatures reached 450 deg., this hardening effect was neutralized and the floats lost strength.

Nickel and New Methods

It seemed that pressures and temperatures would rise beyond the ability of the float but three new developments were progressing that later revolutionized the float industry. These were the Drake process, the art of metal fusion and the art of electrodepositing thick nickel shells.

It was found that a shell of nickel instead of copper deposited on the soldered base would give twice the strength for the same weight. Also the nickel was unaffected by any temperature up to 800 deg. F. so that it retained its cold strength under any existing steam temperature. Still there was the soldered seam underneath, which was a weak point with low factor of safety. Of course, anyone would suggest making a float without any seam or joint and many tried it. But, like the flying machine that could not be developed until the gas engine was perfected, so the really seamless float could be developed only after an efficient form on which to deposit was produced and the art of electroforming heavy deposits of copper and nickel was advanced to a commercial stage.

Depositing a shell of copper on a wax or white metal ball, after which the wax or white metal was melted in an oven and permitted to run out through one or more openings in the shell was tried. These openings had to be of an appreciable size and the trick was to close them effectively. Other difficulties arose in depositing on wax or white metal so that these schemes were never successful. Celluloid was tried as a form on which to deposit but it had many defects and no success was achieved until the Drake process of producing papier-mache or wood pulp forms was developed. This process has been highly developed to produce paper milk bottles, soap containers, peat flower pots, papier-mache toys and hundreds of other articles.

Electro-Deposit on Papier-Mache Forms

In the Drake process, pulp is injected through a specially formed nozzle into a sectional perforated wall mold, distributing evenly over the inside of the mold wall. The machine, which is automatic, Fig. 1, shuts off the pulp supply when the correct amount is injected and opens a supply of superheated air under pressure. Pressure inside the mold forces the water through the perforated wall and the superheated air bakes the pulp to a rigid form of the shape of the mold and a thickness of about $\frac{1}{32}$ to $\frac{3}{32}$ in. depending on the size of the form. The sectional mold opens and drops the mache form, the cycle requiring from 30 sec. to one minute. Ma-

chines are operated in batteries of eight. After leaving the molds, the forms are dried in a steam and air dryer, then stocked and aged until they become hard and firm. These forms, Fig. 3, are light, a 5-in. diam. sphere weighing only ¾ oz. They have an opening in the wall where the injection nozzle entered the mold and over this is cemented a metallic spud or connection, Fig. 4.

This form is now passed through several operations by which the outside is made smooth and the papier-mache impregnated and coated with an acid resistant coating. It is now mounted on a carrying stem, metallized on the outside by a unique process so that it is a chemically clean conductor of electricity and this metallized form on its stem, Fig. 5, is submerged in the depositing solution tank. During the electrodeposition of the metal the float revolves on a spindle which is made the negative or cathode in the electric circuit, the depositing metal in the solution being the positive or anode. Due to revolution of the form and the shape and location of the anodes, a uniform deposit of metal produces a really seamless float.

For low pressure and temperature and where the corrosive properties of the liquid permit, copper is the metal deposited, as it is easy to handle and cheap, with reasonable strength. For high pressures and temperatures and to meet many problems of corrosion, nickel is deposited. It is over twice as strong in the deposited form as copper and can be used at much higher temperatures without losing strength.

Only in the last few years have nickel depositing solutions and nickel anodes been developed to a point where a strong, non-porous, uniform shell could be made. Deposited nickel surpasses copper in the closeness of its crystal structure and, whereas a copper float might in a thin shell show a slight amount of porosity, a nickel shell would be entirely free from porosity, while, for the same weight, the nickel float would be much stronger. At the higher temperatures, the nickel float will maintain its strength while a copper float may slowly anneal and lose strength. Nickel because of its rigidity much better resists denting or damage by rough handling or pounding against the walls of a containing vessel.

Careful laboratory control of the depositing solutions in the tanks is maintained at all times, also of the temperature and of the current density which is in proportion to the surface area of the floats being deposited. Prepared forms go into the tank at a given weight and must be taken out at a given greater weight, depending on the size of the float and the pressure it must withstand. For example, a 5-in. diam. spherical float would be taken out of the copper tank at a weight of 12 oz., if it was designed for 50 lb. working pressure; but it would remain in the tank until its weight was 19 oz., if it was to be used up to 200 lb. pressure. This process is flexible in giving just the right weight and the most buoyancy consistent with strength.

By this process, floats may be deposited to a certain weight with copper, then transferred to the nickel tank for an outer shell of that metal. These composite floats of two metals have met many conditions not solved by other types of float. Sometimes a float must be of a certain weight at a given pressure; for example, a 5-in. float is required to weight 20 oz. in order to open a valve at 100 lb. pressure but it need only weigh 15 oz. as far as strength is concerned. To meet these conditions, 5 oz. of clean dry sand is placed in the form before depositing the metal and a satisfactory float produced at a reduced cost.

Tests for Strength and Leakage

After depositing is finished, the float is checked for weight, then given a test in a special hot oil to detect the slightest leak. Next a test from 50 to 100 per cent in excess of its maximum working pressure is made in a hydraulic test machine. The float is then given an acid dip to improve its appearance and remove stains, followed by a coating of size or lacquer to prevent oxidation. It is then ready for shipment.

These solid shell floats have no seam or joint of any kind, no solder and are in every sense of the word seamless. They are so tough and ductile that they may be hammered out of shape and badly dented without starting a leak, Fig. 6.

By this process spherical nickel floats of 6 in. in diameter with considerable buoyancy have been made that have stood up under 3000 lb. per square inch external pressure. No other process of float construction has been able to develop such strength at the same weight.

Elongated Float Construction

For the type of float having a cylindrical side wall and spherical ends, it is necessary to increase the thickness of the cylinder wall over that of the ends to give uniform strength and minimum weight. As it is difficult to introduce a reënforcing ring into the deposited float a process has been developed of depositing a side wall thicker than the ends.

Another method of producing floats, developed in the last three years, is to draw two cups from sheet metal and fuse them together into one homogeneous piece. The cups are sometimes made of steel welded together and then electroplated to prevent corrosion, or are made of a stainless steel that permits welding. Some stainless steels may be welded so as to give strength but it is uncertain that the weld will be absolutely non-porous, which is more or less true of all welds in steel.

Fusion of monel metal or nickel into a homogeneous mass has been developed absolutely free from the porosity of welds. By this process two cups of monel metal or nickel, Fig. 7, having upstanding edges are assembled together over a metal ring and the edges fused into a homogeneous mass in a special machine, no extra metal being added. During this fusing process it is necessary to have a vent for the expanding air inside the float. A small hole $\frac{1}{16}$ in. in diameter is made in one of the cups, this vent being used later for testing. The float is placed in a tank of water with the fused zone submerged and air under pressure introduced through the vent, so that any defect in the fused zone will be indicated by air bubbles in the water. After this test the vent is closed by a drop of fused silver alloy or nickel. The completed float, Fig. 8, is given the hot oil test for leakage, a hydrostatic test for strength and is cleaned for shipment.

Flow of water, steam or air through an orifice varies as the square root of the pressure difference or drop for small pressure differentials.

High Pressure, Temperature and Load Factor Economy

RECENT advances in pressures and temperatures for steam generation bring up the question of possible gain from such practices.

In a paper before the British Association George A. Orrok discussed this matter, especially as to the effect of load factor or use factor on station economy when using high pressures and temperatures.

Considering the effect of temperatures on heat consumption per kilowatt-hour, the Carnot cycle shows as in Table I:

TABLE I. B.T.U. PER KW-HR.

Temp. deg. F.....	500	600	700	800	900	1000
Carnot cycle	7800	7000	6400	5900	5600	5400
At 85% Thermodynamic Efficiency						
Pressure 3250 lb...	....	....	....	7300	7200	7100
Pressure 1200 lb...	....	....	8400	8300	8100	8200
Pressure 600 lb...	9400	9300	9150	9050	8900	8800
Pressure 300 lb...	10,450	10,300	10,200	10,000	9900	9700
Pressure 200 lb...	11,075	11,000	10,900	10,700	10,400	10,100
At 80% Operating Efficiency, Furnace to Bus Bars						
Pressure 3250 lb...	....	....	....	9100	9000	8900
Pressure 1200 lb...	....	....	10,500	10,350	10,200	10,250
Pressure 600 lb...	11,800	11,700	11,600	11,300	11,150	10,950
Pressure 300 lb...	13,050	12,950	12,800	12,600	12,300	12,100
Pressure 200 lb...	13,990	13,800	13,600	13,300	13,050	12,850

Table I also shows the variation of possible heat consumption at various pressures. First when a thermodynamic efficiency of the cycle is assumed of 85 per cent; second when, in addition, the plant efficiency, furnace to bus bars is 20 per cent. All values assume operation at the most economical load. For 1200 lb. pressure, reheat is assumed for temperatures below 975 deg. and for 600 lb., below 850 deg.

It is impossible, however, to operate even base load plants continuously at most economical load. As a result, some plants for base load are designed with best economy when run at about rated capacity; others, for average use have best economy at 65 to 80 per cent rating; while units which are intended for forcing to carry peaks may have best economy at 50 per cent of maximum rating, or even lower.

To take account of this factor, Mr. Artsay has worked out a somewhat complicated method which takes account of load factor, temperature and pressure, for calculating heat consumption and values computed for best results to be expected at 750 deg. F. temperature are given in Table II. For comparison are given values taken from a curve by Fernald and Orrok, which averages results from records of some 500 plants.

TABLE II. B.T.U. PER KW-HR.

Pressures, lb. gage	200	300	600	1200	3250	Test Curve
Load Factors, %						
10	22,900	21,400	20,500	19,400	18,600	.....
20	18,600	17,300	16,400	15,700	14,300	.....
30	17,200	15,900	15,000	14,100	12,850	25,700
40	16,350	15,100	14,200	13,300	12,050	20,800
50	15,950	14,700	13,800	12,900	11,700	17,900
60	15,750	14,350	13,500	12,650	11,350	16,000
70	15,450	14,150	13,300	12,350	11,100	14,600
80	15,300	14,050	13,100	12,200	11,000	13,850
90	15,200	13,950	13,050	12,100	11,900	13,300
100	15,100	13,900	13,000	12,050	11,850	13,100

Greater increase of heat consumption at low load factors for the best values indicates the difficulty of controlling station losses under actual operating conditions. To make comparison of performance with possibility, the difference between actual heat consumption and that from Table II for the pressure and load factor of the actual plant shows the loss due to operation. The effect of a temperature other than 750 deg. can be estimated from Table I.

Mr. Orrok stated that the loss from operation varies in modern stations from 1000 to 2000 B.t.u. per kw-hr., the recent high-pressure stations all being within the 1000 B.t.u. loss range. He felt that for pressures of 300 to 1200 lb., investment cost may fairly be taken as $100 per kw. of maximum 24-hr. capacity, even though some earlier stations reported higher cost.

Hours of use and price of fuel then become chief factors in generating economy and for a given fuel cost the effect of use factor may be summarized thus: Heat consumption varies with use factor about as shown in Table II.

Roughly, 1000 B.t.u. per kw-hr. will be saved for each doubling of pressure, starting at 200 lb.

About 200 B.t.u. per kw-hr. will be saved for each 100 deg. rise in temperature above 500 deg. F.

Improvement in operation can effect saving of 1000 to 5000 B.t.u. per kw-hr., depending on how well the plant is run before improvement is started.

Commercial Standards for Fuel Oils

REPORT FOR THE FIRST YEAR FOLLOWING THE NEW STANDARDS INDICATES THEY ARE RAPIDLY REPLACING THE OLD MEANINGLESS GRAVITY DESIGNATION

CONSTANTLY INCREASING use of petroleum fuel oils for industrial purposes, increasing and various sources of crude oil from which these fuel oils are produced and the rapidly changing refining operation created a demand for commercial standards to replace the old-time meaningless gravity designation.

Somewhat over a year ago the Bureau of Standards in coöperation with a large number of interested industrial concerns issued Commercial Standards CS-12-29 covering light, medium and heavy domestic and light, medium and heavy industrial fuel for oil burning equip-

DETAILED REQUIREMENTS FOR INDUSTRIAL FUEL OIL UNDER COMMERCIAL STANDARDS CS-12-29 OF THE BUREAU OF STANDARDS

Grade of oil	Flash Point deg. F. minimum	Water and sediment maximum	Viscosity, maximum
No. 4 light industrial fuel oil. (An oil known to the trade as light fuel oil for use in burners where a low viscosity industrial fuel oil is required).....	150(1)	1.0%	Saybolt Universal at 122 deg. F. 125 sec.
No. 5 medium industrial fuel oil. (Same as Federal Specifications Board specification for Bunker Oil "B" for burners adapted to the use of industrial fuel oil of medium viscosity)	150	1.0%	Saybolt Furol at 122 deg. F. 100 sec.
No. 6 heavy industrial fuel oil. (Same as Federal Specifications Board specification for Bunker Oil "C" for burners adapted to oil of high viscosity)..	150	0.25%(2)	Saybolt Furol at 122 deg. F. 300 sec.

1Whenever required, as for example, in burners with automatic ignition, a maximum flash point may be specified. These specifications, however, shall not require a flash point less than 250 deg. F. under any conditions.

2The total water plus sediment shall not exceed 2.0 per cent. Pour point may be specified whenever required by conditions of storage and use. These specifications, however, shall not require a pour point less than 15 deg. F. under any conditions.

ment. Detailed specifications for industrial grades are given in the accompanying table. These oils are specified as hydrocarbon oils free from water, acid, grit and fibrous and other foreign matters likely to clog or injure the burner or valves.

Determination of flash point, water and sediment, pour point and viscosity and the procedure for making the test specified can be found in the publications of the American Society for Testing Materials or from the Technical Paper 323B of the Bureau of Mines.

On this standardization program, the American Oil Burner Association assumed the initiative and developed the specifications with the coöperation of the American Society of Testing Materials, American Petroleum Institute and the Bureau of Standards in order to bring the specifications into broader use.

Fuel oils always have been and always will be residue in the refining of petroleum and if consumers are to obtain the greatest value from their use they must adjust their operations to meet the changes in refining conditions rather than expect the petroleum industry to adjust their operations to meet the consumers' demand.

Almost revolutionary methods in refining, numerous cracking processes now in use and many new crude producing areas have radically changed conditions under which fuel oils are now produced. These conditions have materially changed the inherent chemical and physical properties of these oils so that the gravity designation formerly entirely satisfactory is no longer even an indication of the characteristics of the residuum or fuel oils produced.

Economical purchase of fuel oil should be on a B.t.u. basis. There are many industrial plants that can at comparatively low cost equip themselves with insulated fuel oil tanks and heating equipment to heat any grade of fuel oil to the desired temperature. It is now possible to purchase fuel oil of from 5 to 7 gravity, or even lower, with a heating value as high as 170,000 B.t.u. per gallon and with proper methods handle this oil as easily and economically as 24 to 26 gravity oil of approximately 140,000 B.t.u. per gallon.

Adoption of the new standards, although not universal, has been encouraging. A recent questionnaire indicated that 77 per cent of the output of 29 companies conformed to the commercial standards; replies from 18 companies indicated 100 per cent adherence to the standards; four disregarded the standards entirely and three gave no figures. Reasons for deviation of the standards were given variously as a lack of demand; demands for lower prices; demands for meeting individual specifications and difficulties of meeting the standards with the oil available by the refining method used.

Influence of Use on Gas and Oil Engine Design

Details of Cylinders, Pistons, Shafts, Valves, Frames, Flywheels, Governors and Other Parts, as Determined by Demands on Engine. By Harold F. Shepherd*

INTERNAL COMBUSTION engines have become pioneers in the spread of power over the globe. Every town and village on earth, however, peopled desires water and lighting systems, sanitation and refrigeration. These are necessary adjuncts to health and civilization, even to law and order. These services require some form of economic support such as agriculture, lumbering, fisheries or mining which may include oil or gas production, manufacturing and commerce with its transportation facilities.

In marine service, the Diesel engine has made operation of carriers profitable where once it seemed that our merchant ships must disappear from the seas. The Diesel tanker has become indispensable in the international marketing of petroleum and its products.

Great trawlers and fishing craft of other classes with 500 or more Diesel horsepower farm the oceans and fisherman market as the radio bulletins direct them at sea.

Fishing boats and railroad transportation carry motorized refrigeration. Icing stations driven by Diesel power serve steam trains carrying perishable cargoes across the deserts. Ice, frozen foods and cold storage are available everywhere.

The Diesel locomotive and the internal combustion engined rail car have relieved certain desperate situations in railroad economies. On the arteries carrying gas or liquid fuel which the pumping engines feed, they extract an inconsiderable part of the energy that they move to market. In civil engineering and lesser "contracting" operations, the internal combustion engine has produced profound changes.

*Cooper-Bessemer Corp., Mt. Vernon, Ohio. Abstract of paper presented Feb. 11, 1931, before Fifth Midwest Power Engineering Conference, Chicago, Ill.

The Influence of Use

The needs of the user govern the design and development of the imposing array of engine models offered today. Once we uttered earnest pleas for better environments for our precious engines, but pioneers continued to carry them beyond even the less ordered areas and better engines were evolved. Better operators was once the cry but our mechanized world has advanced with such rapidity that no industry may reckon on journeyman operators or service men.

Fortunately installations and accessories have been wonderfully improved. It is now possible to supply an engine with clean air, cool and clean water, cooled and clarified lubricating oil and clean fuel in almost any situation. The foundations provided whether the concrete of the stationary plant or the steel of ship, locomotive or shovel are good permanent structures.

Simple Engines

The two-cycle engine, compressing its scavenging air or charge ahead of the power piston maintains its place as a popular prime mover in the oil fields and in small manufacturing plants. In principle it has remained much the same for many years, but in its construction every refinement used in building the most sophisticated engines is employed. Its crank shaft is die forged and

heat treated. Cylinders, pistons and rings are ground. Roller bearings serve as main journals. Lubrication of crank and motion work is by a direct flood of oil, all moving parts being fully enclosed.

Admission valves and porting have been carefully studied with the aid of modern indicators and the "port loss" of fuel once characteristic of the type is avoidable at small additional cost by use of gas injection.

The standard rig used for the oil field operations of drilling, bailing, casing, swabbing, pumping, pulling rods and tubing, was originally developed to utilize the reversing steam engine as power. Gas shortage as well as boiler maintenance, labor costs and other economic considerations years ago led to the use of the simpler types of gas engines and oil engines for this service. One operator serves as many as twenty-five rigs and often more.

A reverse system was effected by using a planetary reverse gear and a straight way clutch for ahead motion like the model T transmission. Belt driven rigs generally use 12-ft. band wheels. Chain driven rigs use rig crank shafts having sprockets with about 130 to 140 teeth. As pumping speeds and drilling speeds are comparatively low the engine crank shaft pulleys or sprockets are rather too small for good practise.

A new device incorporates a primary speed change so that the power take-off from the engine may use any desirable size of pulley or sprocket while the engine chosen may be one of high speed for an indefinite prospect or one of moderate speed if the well is expected to produce for 20 yr. or more. Forward motion and reversal are effected by two straightway clutches and chains. Antifriction bearings are used throughout in this device and a pump supplies a flood of lubrication.

Vertical Engines

Design of crank shafts for multi-cylinder vertical engines has been the subject of scientific thought for some years and is just now reaching the state where it can be handled as a matter of drafting room routine.

Modern shafts for engines of six or more cylinders are designed for great torsional stiffness which gives them excess strength and quite large ones are die forged. The stepped shaft has recently come into existence. In these designs, the crank shaft journals are increased progressively in size toward the power take off or fly wheel end.

The box frame is now universally accepted since it is realized that even though an engine is free of external free forces due to reciprocating masses the individual reciprocating systems produce much the same reactions on the multi-cylinder engine frame as they exert on a single cylinder frame.

The question of balance is gradually superseding any prejudice against a multiplicity of parts. The straight eight is firmly established as a marine engine and the six-cylinder engine is now admitted and even preferred in stationary services where the minimum number of cylinders was once demanded. Cork insulated foundations, together with well balanced engines, eliminate all evidence of Diesel power in large city buildings.

Strangely, three-cylinder engines with a free couple of considerable magnitude rather than the purely vertical free harmonics of the four are entirely satisfactory in any service yet attempted.

Large aluminum pistons of the type having steel bands restraining expansion of the split skirt are now established as useful in reducing inertia forces and are reliable in service.

Complete enclosure of all working parts is already a reality for engines upward of several hundred horsepower and will perhaps be the ultimate ideal of all design. This makes possible automatic oiling of every working part from the central system.

Lubricating oil coolers and centrifuges or filters are now as much a part of the engine equipment as the flywheel.

Four years of eminently satisfactory experience with roller chain valve gear drives has resulted in the complete elimination of vertical shafts, spiral gears and bevel gears.

Much attention is given to differing flywheel requirements. For alternators the conditions of cyclical speed variations, angular displacement and resonance must be compromised and in some measure critical speeds are governed by the wheel weight. Yacht engines use a light flywheel enclosed with the thrust bearing. This allows the engine to turn over at one-third rated speed. Large engines required to operate in the Canadian canal systems use great flywheels which keep the engine in motion against compression at speeds as low as one-eighth or one-tenth rated speed. This characteristic is invaluable in locks. Shovel and drag line engines are fitted with flywheels capable of putting out 25 per cent excess energy for a fraction of a second to ease the shock of the recurrent peaks. These wheels and their shafts are considered for "shimmy" and gyroscopic action on bearings.

Gas engines and Diesel engines are required to parallel with every known type of prime mover consequently governing apparatus has been greatly refined.

The governors are mounted in antifriction bearings and every pivot is usually of that type. All shafts transmitting motion to the fuel control mechanism are carried on roller bearings with flexible steel disc type universal joints, having no back lash, between each cylinder unit. Regulation well within any practical requirement is readily accomplished.

Many new vertical engines are designed with convertibility as an objective. If the use of gas only is contemplated large cylinders are fitted to utilize the full strength of the crank shaft and other stressed parts. If conversion is imminent, the smaller Diesel cylinders are fitted at purchase.

Compressor Engines

For refrigeration, foundry use, mining, hard rock work and pumping water or oil; for handling natural or artificial gas, refinery or chemical works gases the direct driven gas engine or Diesel compressor is an economical combination.

The versatility of this general type is remarkable. A 60-hp. unit, self contained, compact and portable, is sufficiently rugged to endure oil field operations for the life of a lease and at the same time a handy and almost indestructible piece of contractor's equipment where much hard rock is to be moved. To shorten the structure a trunk piston is used but yokes on each side of the con-

necting rod and slider provide excellent guiding and stiffness of transmission. This unit operates either as a Diesel engine or a gas engine. To convert it for oil burning, the piston is replaced. The spray nozzle is fitted to the spark plug opening and the fuel pump replaces the magneto.

Twin tandem double acting large capacity unit installation is typical of the sort that is moving gas from the fields where it was once almost valueless to cities hundreds of miles away. The compressor end has been subjected to serious scrutiny for valve action and resistance with much reduction of fluid friction losses. Special metals have been developed to resist corrosive gases. For high pressure work steel cylinders with liners suitable for resisting piston ring wear or corrosion are available. It is not possible to use unlimited clearance in compressors as in pumps, hence pot valve construction is impossible.

Steam Station Economy

LARGE STATIONS SHOW HEAT CONSUMPTIONS RANGING FROM 12,495 TO 17,630 B.T.U. PER NET KW-HR.

COMPLETION of Long Beach Station No. 3, with units 10 and 11, each with a net operating capacity of 100,000 kw., by Stone & Webster Engineering Corp. ended what has been a continuous construction program carried on by them for approximately six and one-half years for the Southern California Edison Co. Some of

OPERATING DATA OF POWER STATIONS

	Columbia	Philo	Long Beach	Cahokia	Hell Gate
1. Installed capacity, kilowatts	90,000	80,000	100,000	145,000	285,000
2. Monthly output million kw-hr.	48.6	36.07	59	38.57	82.9
3. Station capacity factor, per cent	72.7	60.7	89.3	35.8	39.4
4. Steam pressure, lb. per sq. in. gage	600	530	409	304	265
5. Steam temperature, deg. F.	730	706	735	700	610
6. Vacuum, in hg	29.3	29.0	28.51	29.2	28.5
7. Theoretical cycle efficiency, per cent	44.0	42.3	40.9	39.6	35.1
8. Actual thermal efficiency, per cent	27.3	24.0	26.6	20.2	19.4
9. Ratio of thermal to actual efficiency, per cent	62.0	56.7	65.0	51.0	55.3
10. B.t.u. per kw-hr. theoretical	7760	8070	8350	8620	9730
11. Station loss, B.t.u. per kw-hr.	4735	6180	4498	8275	7900
12. B.t.u. per kw-hr. actual	12,495	14,250	12,848	16,895	17,630

the features of this construction program and the records received by the plant are outlined in an article by F. G. Philo, superintendent of steam generation, Southern California Edison Co. in a recent issue of the Stone & Webster Journal.

This new plant No. 3 with an operating capacity of 200,000 kw. was built for approximately $81 per kw. of capacity. Reduction in fixed charges and of operating costs were accomplished by careful design and the use of complete automatic control. The entire station is operated by 15 men on each shift, or one man to every 13,333 kw. of capacity.

Turbines installed here are tandem compound units served by four vertical condensers; steam is supplied by six boiler units, with completely water-cooled furnaces and air preheaters, each boiler capable of delivering a maximum of 450,000 lb. steam per hr. at 450 lb. pressure, 750 deg. F.

Performance data of this and a number of other large stations are given in the table. It should be borne in mind when comparing the performance of the Pacific Coast stations to eastern coal burning stations, that boiler efficiencies when using the better grades of coal will be higher than where fuel oil is used and considerably better than those obtained with natural gas because of the large hydrogen content of the two latter fuels. Natural gas from nearby oil fields constitutes about 99 per cent of the fuel now used in Long Beach.

General use of motor-driven auxiliaries, in the newer Long Beach plants, has been justified by experience. The only weakness of the arrangement at Long Beach was the effect of low frequency during occasional system disturbances. In a few instances, the reduced speed of the main unit resulted in loss of speed of motor-driven centrifugal pumps and fans at a time when their full capacity was needed. This weakness was remedied, however, by the installation of quick starting, stand-by house generators which are normally cold but which can be started and made to assume the full auxiliary power load in less than fifteen seconds.

Three years' service records for unit No. 10, that is, from June 20, 1928, to June 20, 1930, show a total of 50,681 hr. or 88.46 per cent operation. The remaining 11.54 per cent outage was about evenly divided between hours for which the unit was idle and not available for service and hours when it was idle but available for service. The weighted average for a two-year period for the first unit was 12,907 B.t.u. per net kw-hr. During the year 1929 the station load-capacity factor was 81.6 per cent and the efficiency in B.t.u. per kw-hr. 12,848. Station operating results to November 15, 1930, showed a drop in the station load-capacity factor to 62.9 per cent, and an efficiency 13,113 B.t.u. per kw-hr.

TWO VERTICAL Leffel turbines have been installed by the Michigan Public Service Co., Traverse City, Mich., at its No. 3 Boardman River Plant. The Harza Engineering Co., Chicago, Ill., were the engineers for this development, including new dam, power house and hydroelectric equipment.

The turbines were installed in concrete scroll casings and mounted on concrete elbow draft tubes of the latest design. Models of the turbines, scroll cases and draft tubes were exhaustively tested in the manufacturer's new hydraulic laboratory, and these important parts of the installation were definitely determined, before the final plans for the field work were decided upon. These tests developed designs which resulted in considerable savings in concrete and form work for scrolls and draft tubes without detriment to the maximum performance of the turbines.

The turbines are equipped with outside gate operating mechanism, all working parts being readily accessible and fitted with alemite lubrication. The main shaft bearings are the most modern oil lubricated type with full automatic protection against operating emergencies. A vacuum breaker is connected to each draft tube and arranged with very ingenious device to operate synchronously with the governor. The carefully balanced wicket gates are cast steel and the operating mechanism incorporates numerous new and practical refinements.

TURBINES did not begin to appear commercially until the early part of the twentieth century.

Design of Secondary Distribution Systems

PART II. CALCULATIONS FOR THE DESIGN OF A 3-PHASE SYSTEM FOR A CITY OF 120,000

By V. W. Palen

SIMILAR to Design of Secondary Distribution Systems, Part I,[1] this article deals with the electrical and economic phases of secondary design as they concern a power company serving a city of approximately 120,000 inhabitants.

In the case of the single-phase installation, since we decided that a 50-kv-a. transformer was the largest practical to hang on a pole, we found ourselves limited to

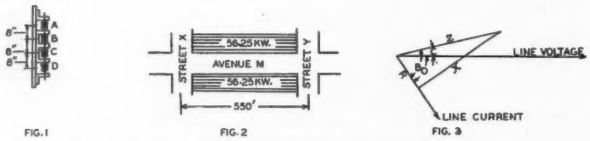


FIG. 1. FOUR SPOOL RACKS USED TO SUPPORT CONDUCTORS
FIG. 2. MAXIMUM LOAD CONDITIONS
FIG. 3. VECTOR DIAGRAM FOR CONDITION INVOLVING NO. 4/0 WIRE AND A LOAD POWER FACTOR OF 90 PER CENT

12½ kv-a. density per block for two-block transformer separation. Likewise, we were limited to 25 kv-a. density per block for one-block transformer separation. In this article the practical limit for a 3-phase single-pole transformer installation was fixed at 3-37½. Thus our single-phase limit of 12½ kv-a. has been increased to 28.125 kv-a. density per block for two-block transformer separation. In a like manner the single-phase limit of 25 kv-a. has been increased to 56.25 kv-a. density per block for one-block transformer separation.

Herein the same conditions govern the study as previously, namely, a standard city block equals 550 ft. in length, secondary wire sizes are No. 4, No. 2, No. 00 and No. 0000. Secondary wire is installed on four spool racks, (see Fig. 1) with the neutral wire at "A." Equivalent wire spacing for reactance calculation is

$$\sqrt[3]{8 \times 8 \times 16} = 10.08 \text{ in.}$$

As above pointed out, the maximum load condition will be 56.25 kv-a. per block (see Fig. 2).

In order to approach normal conditions more correctly, we assume a 90 per cent load power factor and by the following method determine a factor by which to multiply the impedance of the various wire sizes to obtain what we have termed an "effective impedance."

Figure 3, let us say, represents the case of No. 0000 wire with a load power factor of 90 per cent—

Then Cosine O = 0.90

And, from the tables, we find O = 25° 50′

But we know Cosine B = $\frac{R}{Z}$

[1]Page 264, February 15, 1931 Issue.

And, from the tables, we find R = 0.2703 and X = 0.485 (per mile).

Therefore: $\frac{R}{Z} = \frac{0.2703}{\sqrt{(0.485)^2 + (0.270)^2}} = \frac{0.2703}{0.555} =$

0.486 = Cos B

From the tables, we find B = 60° 55′

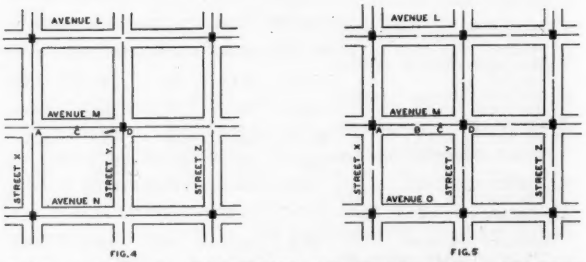
Subtracting, we find B — O = 35° 05′ = Angle L

We therefore multiply impedance of wire (0.555) by Cosine L (0.8183) to get effective impedance, thus:

Eff (Z) = (0.8183) (0.555) = 0.454 ohms/mile = 0.086 ohms/1000 ft.

Table I then is a table of "R," "X," "Z," and "Eff Z" for the four wire sizes under consideration. Values in this table are based on 1000-ft. lengths of single conductor.

In Fig. 4 there is an expanded plan of a typical sec-



FIGS. 4 AND 5. DIAGRAMS OF SECONDARY SYSTEMS TRANSFORMERS

ondary having transformer banks spaced every two blocks along avenues "L," "M," and "O." Each transformer bank will have to carry two city blocks of load along the avenues, plus two city blocks of load along streets "X" and "Y."

For practical purposes, we may assume a uniformly distributed load from "A" to "D" and consider it concentrated at "C" in our computations. Then for our maximum conditions of 28.125 kv-a. per block,

$$I = \frac{28125}{3 \times 110} = 85.2 \text{ amp. per secondary leg}$$

To carry this current, the Underwriters require No. 2 (or larger) rubber covered wire.

Since CD = ½ AD

CD = ½ (550) = 275 ft.

$$\text{IZ Drop} = \frac{275\ ZI}{1000}$$

Where Z = (Eff Z) per 1000 ft.

TABLE I. VALUES OF R, X, Z, AND EFF. Z

Wire Size	Per 1000 Feet			
	R	X	Z	Eff. Z(90% P.F. Load)
4/0	.0512	.0918	.105	.086
2/0	.0812	.0972	.127	.1155
#2	.1593	.1050	.1831	.1830
#4	.2533	.1104	.2760	.2760

If we allow a 2 volt drop on 110 v.:

$$2 = 23.4\ Z$$

$$Z = \frac{2}{23.4} = 0.0855 \text{ ohms per 1000 ft.}$$

From Table I, we find No. 0000 has an (Eff Z) of 0.086 ohms per 1000 ft. It is, therefore, barely possible with No. 0000 to guarantee that the drop of 2 v. on 110 be not exceeded.

Our next consideration is to place the transformer banks one city block apart, as shown in Fig. 4. From this we see that each transformer bank must carry one city block of load along the avenues "L," "M," and "O," plus one city block of load along the streets "X," "Y," etc.

Now CD = ½ BD = ½ (275) = 137½ ft.

Since our maximum load now becomes 56.25 kv-a. per block = 28.125 kv-a. per ½ block.

$$I = \frac{28125}{3 \times 110} = 85.2 \text{ amp. per secondary leg}$$

It is interesting again to note that the Underwriters require No. 2 (or larger) rubber covered wire to carry this current.

$$\text{IZ Drop} = \frac{137.5\ ZI}{1000}$$

Where Z = (Eff Z) per 1000 ft.

If we allow a 2-v. drop on 110 v.

$$2 = 11.7\ Z$$

$$Z = \frac{2}{11.7} = 0.1710 \text{ ohms per 1000 ft.}$$

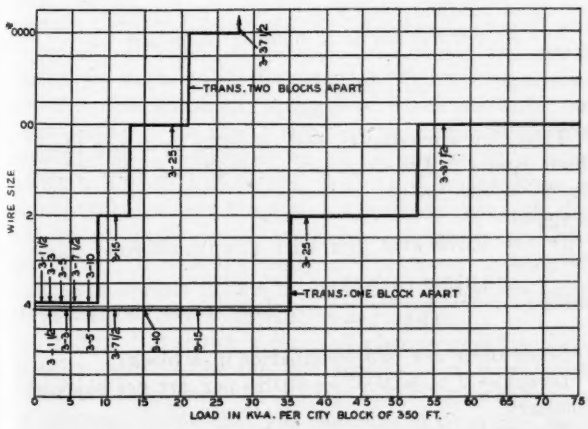


FIG. 6. CHART SHOWING RELATION BETWEEN WIRE SIZE AND KV-A. IN A CITY BLOCK

From Table I, we find No. 2 has an impedance of 0.1830 ohms per 1000 ft. and No. 00 has an impedance of 0.1155 ohms per 1000 ft.; therefore, No. 00 (or larger) will be required to guarantee that the drop of 2 v. on 110 be not exceeded.

For finding the core and copper losses, the relative costs of wire and the relative cost of transformers, Tables II, III and IV shown in the previous article (Part I, Feb. 15 issue) are used. The calculations are as follows:

Core loss = 105 × 24 = 2520 w-hr. = 2.52 kw-hr.
Copper loss = 233 × 4 = 932 w-hr. = 0.932 kw-hr.
All-day loss = 2.52 × 0.932 = 3.452 kw-hr.
Total power delivered = 15 × 4 = 60 kw-hr.

$$\text{All day Eff} = \frac{60}{63.452} = 94.7 \text{ per cent.}$$

FIG. 7 FIG. 8

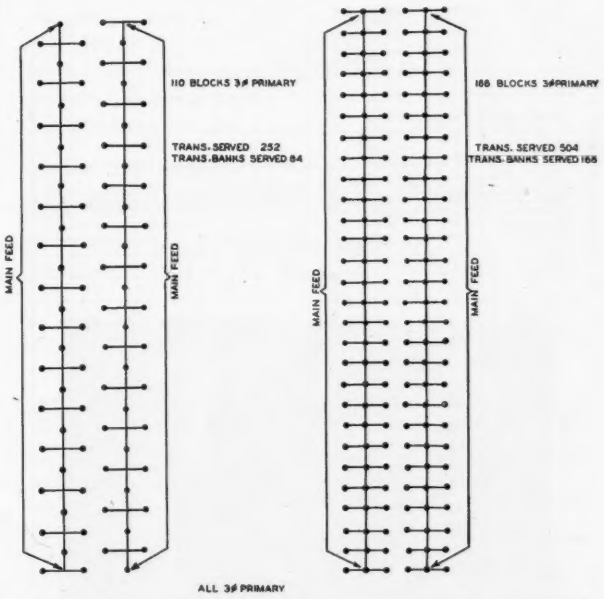


FIG. 7. METHOD OF SERVING TRANSFORMER BANKS WITH PRIMARY FOR TWO BLOCK SPACING
FIG. 8. METHOD OF SERVING TRANSFORMER BANKS WITH PRIMARY FOR ONE BLOCK SPACING

The cost per day for transformer losses is figured, therefore, for a bank of three 37½-kv-a. transformers, as follows:

For two-block transformer bank spacing, since each transformer bank feeds four blocks of secondary, ¼ of the total capacity of the bank is required per block.

$$\text{With } 3\text{—}37\tfrac{1}{2}, \frac{3 \times 37\tfrac{1}{2}}{4} = 28.125 \text{ kv-a. load per block}$$

and all-day losses on 37½ kv-a. transformer (from Table IV (Feb. 15 issue) are 6.50 kw-hr.

$$\text{Therefore, } \frac{6.50 \times 3}{4} \times \$0.01 = \$0.04875 \text{ per day per block of secondary.}$$

In the case of one block transformer bank spacing, since each transformer bank feeds two block of second-

ary, ½ of the total capacity of the bank is required per block, thus:

With 3—37½, $\frac{3 \times 37\frac{1}{2}}{2} = 56.25$ kv-a. load per block

and $\frac{6.50 \times 3}{2} \times \$0.01 = \$0.09750$ per day per block of secondary.

Figure 6 is a chart plotted between wire size and kv-a. per city block. The arrows indicate the limits of the various transformer banks and the curves show the limits of the various wire sizes for one and two-block transformer bank spacing. These curves are on the basis of a maximum drop of 2 v. on 110 v.

Figure 7 shows the method of serving the trans-

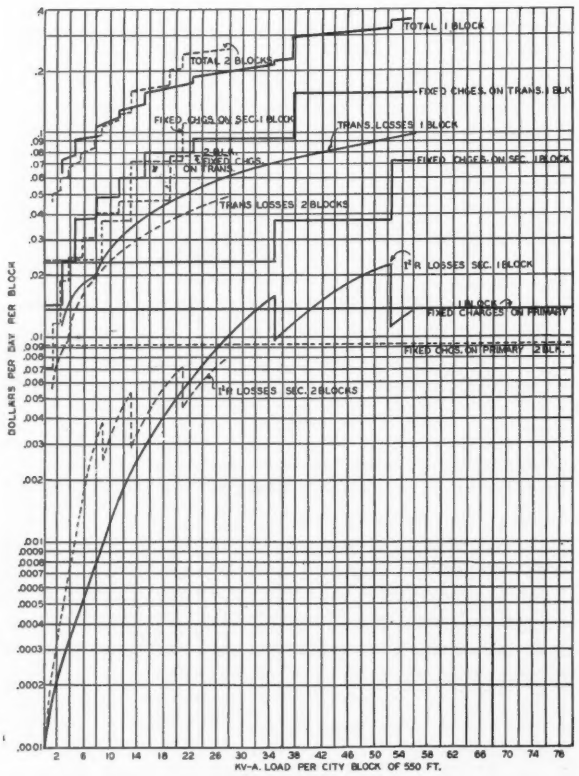

TOTAL 1 BLOCK
TOTAL 2 BLOCKS
FIXED CHGS. ON TRANS. 1 BLK
FIXED CHGS. ON SEC. 1 BLOCK
TRANS. LOSSES 1 BLOCK
2 BLK. FIXED CHGS. ON TRANS.
FIXED CHGS. ON SEC. 1 BLOCK
TRANS. LOSSES 2 BLOCKS
I²R LOSSES SEC. 1 BLOCK
1 BLOCK FIXED CHARGES ON PRIMARY
FIXED CHGS. ON PRIMARY 2 BLK.
I²R LOSSES SEC. 2 BLOCKS
DOLLARS PER DAY PER BLOCK
KV-A. LOAD PER CITY BLOCK OF 550 FT.

FIG. 9. COSTS OF SECONDARY I²R AND TRANSFORMER LOSSES

former banks with primary for two block spacing. In this case there are 110 blocks of 3-phase, which equals 330 blocks of single conductor.

Since there are 84 transformer banks served in this area:

$\frac{330}{84} = 3.925$ blocks single conductor per transformer bank

But each transformer bank serves four blocks of secondary, therefore:

$\frac{3.925}{4} = 0.982$ block single conductor per block of secondary.

If we use No. 2 primary, costing \$41 per 1000 ft., fixed charges amount to:

$\frac{0.982 \times 550}{1000} \times \$41 \times \frac{0.15}{365} = \$0.0091$ per day per block of secondary.

Figure 8 shows the method of serving the transformer banks with primary for one block spacing. In this case there are 166 blocks of 3-phase, which equals 498 blocks of single conductor. Since there are 168 transformer banks served in this area:

$\frac{498}{168} = 2.965$ blocks single conductor per transformer bank.

But each transformer bank serves two blocks of secondary, therefore:

$\frac{2.965}{2} = 1.482$ blocks single conductor per block of secondary.

Again using No. 2 primary at \$41 per 1000 ft., we find that the fixed charges amount to:

$\frac{1.482 \times 550}{1000} \times \$41 \times \frac{0.15}{365} = \$0.01375$ per day per block of secondary.

It can be shown that for a uniformly loaded wire the losses amount to:

$$\frac{I^2 r 1}{3}$$

and for three wires:

$$\frac{3 I^2 r 1}{3} = I^2 R$$

Where I = maximum current in wire
and R = total resistance of one wire

For two-block transformer bank spacing R = resistance of 550 ft. of wire and I may be put in terms of kv-a., and assuming \$0.01 per kw-hr. for energy:

Cost per day for I^2 R losses in secondary =

$$\frac{\text{kv-a.}^2 \text{ (r per 1000')}}{550}$$

Thus, for maximum load of 28.125 kv-a. per block (from Fig. 6) we use No. 0000.

28.125 kv-a. per block $= \frac{28.125}{3} = 9.375$ kv-a. per wire per transformer bank.

Losses $= \frac{(9.375)^2 (0.0512)}{550} = \$0.00818$ per day per block of secondary.

For one block transformer bank spacing R = resistance of 275 ft. of wire and may be put in terms of kv-a., and assuming \$0.01 per kw-hr. for energy:

Cost per day for I^2 R losses in secondary =

$$\frac{\text{(Kv-a.)}^2 \text{ (r per 1000')}}{1100}$$

Thus, for a maximum load of 56.25 kv-a. per block, which equals 28.125 kv-a. per ½ block and since (from Fig. 8) we use No. 00:

$\frac{28.125}{3} = 9.375$ kv-a. per wire per transformer bank.

Losses $= \frac{(9.375)^2 (0.0812)}{1100} = \$0.0065$ per day per ½

Since there are two secondaries in a block:

Losses = 2 × \$0.0065 = \$0.013 per day per block of secondary.

The fixed charges on transformer banks for two-block spacing are figured in the following manner:

Since each transformer bank feeds four block of secondary, ¼ of transformer bank cost is charged to each block of secondary. Thus for a bank of 3—37½ each of which (from Table II, Feb. 15) costs $251—

$$\frac{\$251 \times 3 \times 0.15}{4 \times 365} = \$0.07725 \text{ per day per block of secondary.}$$

The fixed charges on transformer banks for one-block spacing are figured in the following manner:

Since each transformer bank feeds two blocks of secondary, ½ of transformer bank cost is charged to each block of secondary. Thus for a bank of 3—37½ each of which (from Table II, Feb. 15) costs $251—

$$\frac{\$251 \times 3 \times 0.15}{2 \times 365} = \$0.15450 \text{ per day per block of secondary.}$$

The fixed charges on wire are figured the same way for both one and two-block transformer bank separation. Thus for No. 0000:

Length of secondary (1 block) = 550 ft.
Length of single conductor = 4 × 550 = 2200 ft.
Cost of No. 0000 = $122 per 1000 ft. (from Fig. 9).

$$\frac{0.15 \times \$122 \times 2200}{365 \times 1000} = \$0.110 \text{ per day per block of secondary.}$$

By the methods outlined in the foregoing, therefore, Fig. 9 was developed. This chart shows costs of secondary I^2R and transformer losses; fixed charges on primary, secondary and transformers, and totals for one and two-block transformer bank separations for various loads per city block.

In examining the total curves, we note that they cross at 13 kv-a. per block and that for loads less than 7.5 kv-a. per city block two-block transformer bank spacing is most economical. Likewise, for loads greater than 13 kv-a. per city block, one-block transformer bank spacing is most economical. For loads from 7.5 to 13 kv-a. per city block, the costs for two-block and one-block transformer bank spacing are very nearly the same.

Again studying Fig. 6, we come to the conclusion that with conditions as shown herein, apparently the most practical program to follow is as follows:

Install no larger than No. 2 secondary when load and voltage conditions necessitate change from two-block transformer bank separation to one-block transformer bank separation.

Electricity---What It Is and How It Acts*

PART XLIX. THE SIGNIFICANCE OF MOSELEY'S CRITICAL INVESTIGATIONS ON X-RAY SPECTRA OF THE ELEMENTS. BY A. W. KRAMER

NOW, WHAT ABOUT MOSELEY? Several times in the course of this discussion of X-rays and crystal structure, we have had occasion to refer to H. G. Moseley and his work, but so far we have not described just what he accomplished. This we shall do in the present chapter. The principal reason for our digression was to explain more clearly the fundamental principles involved in X-ray diffraction—the phenomenon which enters so vitally into Moseley's work.

The principle of X-ray diffraction by natural crystals provided us not only with a means of investigating the inner structure of crystals but also gave us a method whereby the frequencies of a beam of X-rays could be accurately measured. It will be recalled from the previous chapter that the X-ray tube is characterized by certain frequencies or groups of frequencies which are superimposed upon this the so-called "white" or general radiation of the tube. These characteristic frequencies serve to distinguish the material of which the target or "anti-cathode" in the X-ray tube is made. Thus the characteristic frequencies in the spectrum of a tube using a copper anti-cathode will be different from a similar tube using a tungsten anti-cathode, although the conditions under which the tubes operate are exactly the same. It was the study of the X-ray spectra of various materials in this manner that formed the basis of Moseley's famous investigations in 1914.

In Fig. 1 is shown a series of photographs taken by Moseley which show the line spectra of a number of different substances. At the top, is the X-ray spectrum of calcium. Below that, the spectrum of titanium; then

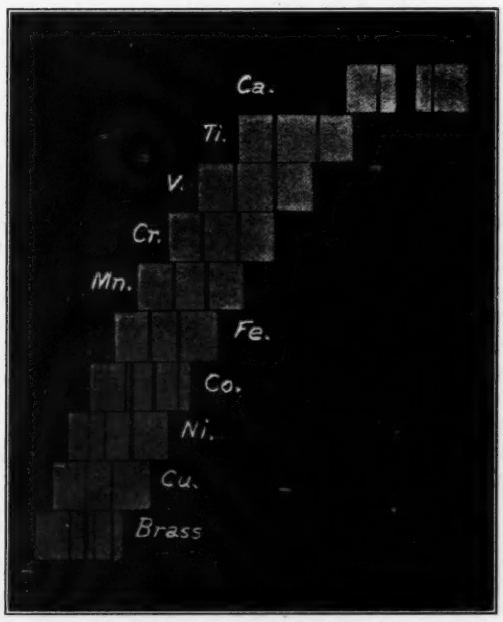


FIG. 1. MOSELEY'S PHOTOGRAPHS OF THE X-RAY SPECTRA OF VARIOUS METALLIC ANTI-CATHODES

In interpreting the significance of these photographs it must be understood that each one consists of a horizontal strip the full width of the rectangle and that they are placed approximately in register.

vanadium, chromium, manganese, iron, cobalt, nickel, copper and finally that of brass.

Most of these, it will be noted are much alike, consisting of two principal lines although sometimes there

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are more. This in itself means little but when a number of such spectrograms are arranged one above the other in the order that the elements would occupy in the periodic table,[1] a striking fact is noted—there is a uniform displacement between the lines. This is shown a little more clearly perhaps in Fig. 2 which is a drawing of a number of such spectrograms, with an arbitrary frequency scale below. It will be noted that as the atomic weights increase, the frequencies increase, causing the successive spectra to be shifted towards the left. The significant thing about this is that the amounts of these shifts are approximately the same.

Discovery of Relation Between Frequency and Element's Place in Table

Moseley proceeded to photograph the X-ray spectra of as many elements as his facilities permitted and in all cases he found this simple relationship between them. He discovered that there was a definite relation between

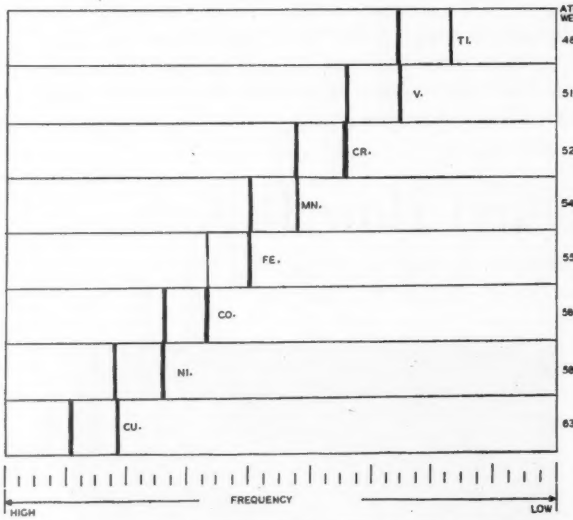


FIG. 2. DIAGRAM SHOWING THE DISPLACEMENT BETWEEN X-RAY SPECTRA. BASED ON MOSELEY'S PHOTOGRAPH SHOWN IN FIG. 1

successive elements in the periodic table which was proportional to the square root of the frequency and found, furthermore, that all the elements could be arranged in the order of their frequency relations, beginning with hydrogen as one and ending with uranium as 92.

At the time that Moseley conducted his researches, a number of elements (about seven) were missing and where these gaps occurred in the periodic table there also occurred gaps in the frequency relations of the elements. Subsequently some four of these missing elements were discovered and these fitted perfectly into the gaps which had been reserved for them.

In short, what Moseley found was this: When the elements were arranged in the order of their characteristic X-ray frequencies, each one is obtainable from its predecessor by simple addition.

This discovery of a simple numerical relationship between the characteristic frequencies of the elements was of far reaching importance, for it indicated that whatever within the atom was responsible for the production of radiation, this varied a certain definite amount from one atom to another. It showed that there was some simple relationship between the atoms of various elements, such as had been suspected from the order of the atomic weights in the periodic table but which from the evidence of the X-ray spectra was far more orderly than that indicated by the atomic weights.

In the periodic table as enunciated by Mendelieff, there was an obvious relation between the atomic weights of the various elements but from the first, it had been evident that the degree of uniformity in these relations was not of an accuracy such as to permit of definite conclusions being drawn. In the first place, hydrogen with an atomic weight of 1.008, is without a place in the table. Again, there are three distinct exceptions to the arrangement of the elements in the order of their atomic weights. Reference to the table[1] will show that tellurium (Te) precedes iodine (I) although the latter has the lower atomic weight. Argon (A) (atomic weight 39.9) precedes potassium (K) (atomic weight 39.1) and cobalt (Co) (atomic weight 58.99) precedes nickel (Ni) (atomic weight 58.69).

Before Moseley's investigations, these discrepancies in the structure of the periodic table could not be accounted for satisfactorily but with the discovery of the frequency relation between the X-ray spectra, the mystery disappeared for this showed that it is not the atomic weight that determines nearly all the properties of the elements but another factor known as the atomic number. The atomic number is derived directly from the frequency relation discovered by Moseley and represents the constant difference between the square root of the frequencies of successive elements.

Thus, we have the proof and reason for the system of classifying the elements according to the atomic number. Moseley's investigations and the researches of others that followed may be considered the first definite proof that the nucleus of the atom is composed of grains of positive electricity—protons.

This had been suspected but never proved. There was plenty of evidence to show the existence of the electron, that is the negative electron, in fact, this had been isolated and measured and much was known about it for a long time. The isolation of the positive electron, the proton, however, has never been accomplished—that is, it has never been separated from matter. Indeed where positive charges have come under observation they have been found always in conjunction and associated with atoms. All elements retained their respective masses intact after ionization, i.e., after experiencing the loss of one or more electrons; it was only logical to infer, therefore, that the positive charges are coupled with and are part of the residual "material" mass of the elements. The lightest known element was hydrogen. Since all attempts to withdraw more than a single electron from the hydrogen atom proved futile, it was established that the hydrogen atom had only one electron and if this was so, then, after the removal of this electron, what remained must be its positive counterpart—the positive electron or proton.

This conclusion was strengthened subsequently in investigations with radioactive substances, for it was shown that certain of the radioactive rays[2] were nothing more than ionized atoms of helium and these were

[1]See Part XXXVI, March 15, 1930 issue.

[2]Part XXXVII, April 1, 1930 issue.

shown to carry a strong positive charge. It was also noted that the net nuclear charge of an atom, that is the number of the unit positive charges centralized at the core of the several atoms as determined by Alpha ray deflections, increased with ascending atomic weights of the elements. It was this that led van der Broeck to suggest that the number of charges upon an atomic nucleus is comparable to the position number of the element in the periodic table.

Moseley's critical investigations confirmed all this to a degree which left no further room for doubt. It was known that radiation such as light and X-rays is the result of displacement of electrons within the atom. Now it is obvious that the greater the positive charge on the nucleus of an atom the greater will be the restoring force and the more rapid the vibrations when the inner electrons are displaced. This accounts for the fact that the atoms of higher atomic number produce the highest frequencies.

It will be recalled from the discussion of this subject in the earlier chapters of this series[3] that the atomic number is a measure of the net charge on the nucleus of the atom and this in turn governs the number of external electrons in the neutral atom.

So it seems we have come back to our starting point. We began with a discussion of the structure of the atom, showing how the number of external electrons was related to the charge on the nucleus and how this charge was a function of the difference between the number of positive and negative electrons in the nucleus. On the basis of this atom, we proceeded to explain chemical action and the passage of electricity through gases, liquids and solids and finally how disturbances within this atom gave rise to electromagnetic radiation in all its various forms. And now, using this same electromagnetic radiation, measuring its frequency by the spacing of the atoms in crystals, we find the proof of the atomic structure we started out with.

We have endeavored to explain electrical phenomena in all its various forms, from the simple electrification of a piece of amber to the transmission of intelligence around the earth by means of electric waves. All of these things we have found are related—electricity is the same no matter in what connection it is studied and its action follows laws which are inviolable. If Ohm's law governing the relation between the current, voltage and resistance in solid conductors fails to hold for gaseous conductors, it is not because electricity behaves differently (that is in accordance with different laws) in gases than in solids, but merely that Ohm's law does not tell the complete story. Neither does it imply that Ohm's law is incorrect—it is correct for the purposes for which it is commonly used, but it cannot be applied in all cases.

We have found not only that electrical phenomena of all kind is related but also that it is related to all things. We cannot discuss electricity without discussing the structure of matter. Neither can we explain radiation in its various forms without discussing electrical phenomena; and the same holds true for radioactivity and magnetism. The electron is the universal element out of which all things in the universe are made and which gives rise to and controls all physical phenomena.

[3]Chapter III.

Now what is the electron? We have reserved this question for the last, first because nobody can answer it and secondly because we had no right to ask it until we knew as much about the action of the electron as we could possibly know. And we shall make no pretense of being able to answer it.

All we know is that the electron is a manifestation of energy and if we are ever to have an explanation we will have to learn more about the meaning of energy. In the explanation of energy lies the master key to the universe.

In the few chapters that remain to complete this series, we shall discuss some of the modern views and theories of energy and its relation to the universe, not with the hope of being able to solve these mysteries, but because they have a bearing on our outlook in life and our own relation to the universe.

Standard Color Code for Control Cable

By G. Sutherland*

THE STANDARD COLOR scheme for control cable presented below was prepared by a joint committee of N.E.L.A. and N.E.M.A. following an extensive review of questionnaires sent to 26 leading American utility companies and a survey of field tests conducted by the joint committee. It has been approved for national use by the N.E.L.A. Electric Apparatus Committee and by the Power Cable Group of the N.E.M.A.

Answers to the questionnaire disclosed the prevailing practice of these companies while the joint committee field tests eliminated many of the objectionable color features still found in use. The table, therefore, is based upon the combination of the best modern practice and experience found in these two national associations. Having been prepared by operating engineers to overcome many of the past objections to colored control cable, it is not feared that much trouble will arise in fitting this color scheme into existing systems since it retains the essential features now used by 20 large operating companies. Neither is it expected that old installations need be changed over to this color scheme but it is hoped that future new construction will follow the new standard.

Answers to the questionnaire disclosed such a large degree of uniformity of colors up to 20 conductors that it was merely a case of holding field tests to determine which colors could be most easily picked out when badly soiled and under poor lighting conditions. It was not a case of working with unknown material because a large number of leading operating companies have been utilizing colored control cable for many years. So few companies reported the use of a spotted and stripped color scheme that it was not considered necessary to study this method in further detail. It was a case of coordinating the best practice and preparing a specification to secure the proper color and tracer stripe arrangements. The colors finally chosen appear in the accompanying table. While the order of color cabling has

*New York & Queens Electric Light and Power Co.; Chairman N.E.L.A. Electrical apparatus committee.

been changed somewhat, the majority of colors used by the 20 above mentioned companies are still listed in the table.

The basic colors are arranged in the order of their cabling—the more commonly used being assigned the lower numbers. The cables in a 6-conductor braided cable, for example, will thus utilize the first six basic colors: black, white, red, green, orange and blue. For a 21 conductor cable; the first 21 color combinations will

STANDARD COLOR SCHEME FOR CONTROL CABLE

	BASE	TRACER	TRACER
1.	BLACK		
2.	WHITE		
3.	RED		
4.	GREEN		
5.	ORANGE		
6.	BLUE		
7.	WHITE	Black	
8.	RED	"	
9.	GREEN	"	
10.	ORANGE	"	
11.	BLUE	"	
12.	BLACK	White	
13.	RED	"	
14.	GREEN	"	
15.	BLUE	"	
16.	BLACK	Red	
17.	WHITE	"	
18.	ORANGE	"	
19.	BLUE	"	
20.	RED	Green	
21.	ORANGE	"	
22.	BLACK	White	Red
23.	WHITE	Black	"
24.	RED	"	White
25.	GREEN	"	"
26.	ORANGE	"	"
27.	BLUE	"	"
28.	BLACK	Red	Green
29.	WHITE	"	"
30.	RED	Black	"
31.	GREEN	"	Orange
32.	ORANGE	"	Green
33.	BLUE	White	Orange
34.	BLACK	"	"
35.	WHITE	Red	"
36.	ORANGE	White	Blue
37.	WHITE	Red	"

be used. It will also be noted that the tracer development follows the same orderly layout as the basic colors.

The field tests consisted of deliberately soiling two comparative sets (A and B) of differently colored samples with dirt, grease and oil to approximate conditions usually found around switchboards. Set A consisted of a scheme using a 50 per cent distribution of colors for two color combinations and a 33⅓ per cent distribution for three color combinations. Set B consisted of the regular basic colors with one or two tracer stripes. Each set was jumbled up in a heap. Maintenance men and installers were asked to pick out and arrange the cables in the order of the table, each complete operation being timed for each individual. The lighting was also varied from good daylight to average artificial lighting such as found behind switchboards and in vaults or manholes.

It was found that such hues and color combinations as brown, violet, yellow and white, green and blue, blue and black, green and black, green and lavender fail very badly to show up their identity under poor artificial lighting. The men would invariably stumble over these colors and take a longer time than when picking out the more pronounced hues. Tests on orange and yellow colors proved that the orange was the most distinctive. The most troublesome color combination for the men to determine was one using green with a blue tracer. Each man insisted that he found only one color until, coming to the end of his table, the omission was discovered.

Time comparison tests on new, unsoiled cables were also conducted. When choosing colors under Set A, the 50 per cent color combination group, it was discovered that considerable trouble was experienced. As there was no predominating color to use as a base, the eye required a longer time to grasp the color distinction than in Set B which employed a base color and a tracer stripe. In the latter case, the men would look first for the solid base color and then seek the tracer. The men expressed a decided preference for the tracer stripe scheme, claiming it much easier to handle.

Another important reason for choosing the tracer stripe scheme was the ease in expanding the color group above 21 conductors. By using a tracer stripe method, the manufacturers are able to make a cable having 100 separate and distinct color combinations. Hence the 50 per cent, 33⅓ per cent color scheme was discarded in favor of the tracer stripe method.

Once having determined the colors desired, it next became necessary to set up a definite standard for securing the exact hue and shade. Reference was made to the standard color card issued by the Textile Color Card Association of the United States, 200 Madison Ave., New York, N. Y., which is accepted as a standard throughout the textile field. This card definitely assigns a specification number to each of the 200 different hues. The joint committee studied this card and picked out a definite specification number for each of the five chosen basic colors: white, red, green, orange and blue, thereby automatically requiring all colored control cable manufactured in different parts of the country to be uniform in hue.

Another important element requiring a rigid specification was the width of the tracer stripe. If only one carrier thread were used, it soon became indistinct when soiled. Two threads improved the distinction a little better but three carrier threads were found to be preferable. Hence it was written into the specification as ". . . the tracer stripe shall consist of three carriers . . ." On cables above 21 conductors, another tracer stripe, also three carriers wide, is to run crossing the first stripe. The distinct choice of three carriers to form the tracer stripe avoids a possibility of confusing faded or dirty stripes which would occur if only one colored carrier were used.

Requirements for Refrigerating Plant Drives

THE AUTHORS, BOTH WITH I. P. MORRIS & DE LA VERGNE, INC., HAVE HAD EXTENSIVE EXPERIENCE IN ENGINE AND REFRIGERATING PRACTICE, SHOW THAT PRIME MOVER EFFICIENCY IS NOT THE ONLY FACTOR THAT MUST BE CONSIDERED. BY OTTO NONNENBRUCH AND C. R. NEESON

SELECTION of oil engine drive for compressors and auxiliaries in the refrigerating plant depend largely upon the individual design. In some plants, the only problem is the main compressor drive, in others the auxiliaries must be considered. If the auxiliaries are driven by separate electric motors, it is frequently necessary to install an electric generator on the oil engine shaft. In some cases, certain auxiliaries may be driven from the engine by a belt, or several auxiliaries may be belt-driven by a lineshaft; in still others, both compressors and auxiliaries are motor driven.

To make the connection between the engine and the compressor, the simplest arrangement is to shrink the compressor crank on the end of the oil-engine shaft. In this type of installation, the flywheel may be replaced by a suitable generator with a small auxiliary wheel for driving an exciter set by means of a belt. A customary method of connecting vertical engines and vertical compressors is by means of a flexible coupling. Sometimes a compressor is driven from each end of the oil-engine shaft.

Vertical engines offer certain advantages for ammonia compressor drive where auxiliaries are required. Present-day design of ammonia compressors permits maximum speeds in the neighborhood of 400 r.p.m. in the smaller sizes. Engines may be obtained to operate at this speed, although slower speeds are the usual practice. This speed difference makes it difficult to find an engine of suitable power to fulfill the exact compressor requirements in every case and it is sometimes desirable to connect an engine to a compressor by belt drive.

Where belt drives for auxiliaries are not desirable, it is often possible to install a separate engine and generator set to take care of auxiliary loads. This set can then operate at the constant speed best suited to the generator, while the engine and compressor units may be run at any speed to suit the requirements of the refrigerating load.

When a generator is either directly connected or belt-driven from an engine shaft, it is sometimes necessary to run the engine at constant speed in order to hold up the voltage on the generator. It is desirable under certain conditions of reduced refrigerating load, however, to reduce the capacity of the compressor and the best method of accomplishing this under constant speed is by means of clearance pockets. Such pockets reduce the volumetric efficiency of the compressor with consequent reduction in capacity. They have been standard practice on horizontal compressors for a number of years but are a recent development on vertical compressors.

When an engine drives a compressor, it does not have clearance pockets or for closer regulation, when clearance pockets control give this, regulation can be secured by adjusting the speed on the engine to suit condition. Engine governors to do this are entirely practicable and may be used where required, although there is, of course, a minimum speed below which the engine will not run.

If electric power is to be obtained from the main engine drive, it is necessary in case of variable speed engines to use a variable speed direct-connected generator. Generators of this type are obtainable for a speed range from maximum down to about 70 per cent of maximum.

Oil engines are not recommended for overload, even for a short period of time, so that the maximum horsepower the compressor may require under any operating condition is a factor that should be carefully considered. The engine should have sufficient power at its normal rating to drive the compressor under any load that may be imposed upon it. The mean effective pressure of an ammonia compressor will vary from 80 to 100 lb. per sq. in. depending upon the conditions of operation, that is to say, back pressure and head pressure.

If a refrigerating plant is shut down, the back pressure and discharge pressure are equalized. The compressor when started up will go through a period of maximum horsepower requirements due to the high discharge pressure caused by insufficient condenser surface for the required capacity and high suction pressures. If this condition is likely to exist for any length of time, the engine must have sufficient power to drive the compressor at maximum power demands.

An ice plant, on the other hand, operates during the greatest part of the year at normal rating. In this case, an engine of horsepower just slightly in excess of the normal load may be supplied, and in the case of shutting down and restarting the operator may adjust his stop valves so that the suction pressure does not become excessive and the load on the engine does not go above its normal rating.

High-speed machinery is less expensive than low-speed machinery, consequently it is more economical to install relatively high-speed engines. These engines may or may not set up soil vibration depending upon several factors. The most important being the number of cylinders. Vibrations are of two kinds, those which tend to shake the engine in a vertical or horizontal direction and the other which tends to rock the engine longitudinally. The former is usually more serious.

Single-cylinder engines should not be run at high speeds. Two-cylinder engines with cranks in line are similar to the single-cylinder engine as regards vibration. Three-cylinder engines have all forces balanced and they are not inclined to produce serious vibration. Four cylinder, four-stroke engines have unbalanced forces. Five-cylinder engines have their forces balanced, while six and eight-cylinder, four-stroke engines are completely balanced. The ice machines themselves are not likely to cause vibration trouble because of their relatively low piston speeds.

Correct foundation design can do much to reduce or eliminate vibration. It is important that no building wall footing or column rest upon or touch the engine foundation as any vibration would be transmitted to the

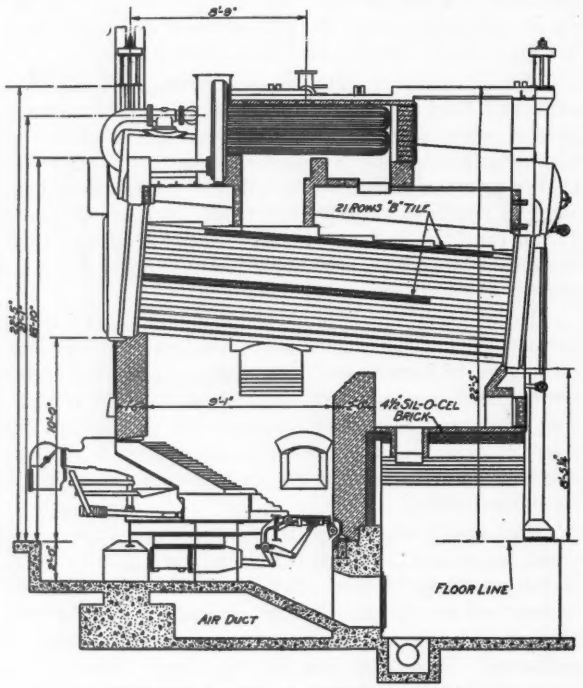
Abstract of paper presented before the N.A.P.R.E. at Memphis, Tenn.

building. Not less than 6 in. of dry earth should separate these parts.

It is sometimes desirable to insulate the foundation from underlying rock or concrete mat by means of cork sheathing. This cork may be some three or four inches thick at the bottom and carried around the sides of the foundation with somewhat less thickness than on the bottom. The cork has a property of absorbing the high frequency vibrations and cork has been used with conspicuous success in a number of instances where vibration could not be tolerated.

Refractory Cement Reduces Upkeep Expense on Boiler Furnace*

BECAUSE the same quality of good fire brick has been used in the boiler furnaces for over 20 yr., fair comparison of the effect of using fire clay and a high temperature refractory cement for laying up settings is possible. Records of costs of material and labor for repairs, also of periods between repairs have been carefully kept, so that conclusions are felt to be reliable.



SETTING OF 600-HP. HEINE BOILER

In the boiler plant of the Cambridge Electric Light Co., which supplies the entire city with electricity and has recently been connected to Harvard University, are installed six boilers. Four are Babcock and Wilcox, rated at 400 hp., of which two were installed in 1906 and two in 1909. Two boilers are 600-hp. Heine units, installed in 1920, the setting being shown in Fig. 1.

Two additional units are now under way to replace four old boilers, which were installed in 1901.

Run-of-mine bituminous coal is fired by underfeed stokers, the boilers being run at 175 to 200 per cent of rating and all boilers being kept on the line at all times, except for the low-load period from 12 p. m. to 5 a. m. or when urgent repairs necessitate a shut-down.

Load during the day is fairly steady but in winter a peak exists from 3 to 5 p. m., due to overlapping of industrial and domestic loads. During the low-load period, fires are cleaned, one by one and boilers put back on the line at full pressure but fires in two are banked until 5 a. m., when they are started and pushed hard to carry their share of the load. Boilers are rotated in banking so that each setting gets the same hard experience of cooling down and rapid temperature rise.

Steam is generated at 200 lb. and 85 deg. F. superheat, furnace temperature running up at 3200 deg. F. during heavy load periods.

Up to 1923, fire clay was used in laying up settings. Replacement with J-M No. 31 refractory cement then began and has increased so that since 1926 only the refractory cement has been used. Bricks are immersed in a batter of the cement, then tapped into place. Since 1926 no entire side wall has needed replacement but repairs are required from time to time on portions of the side walls and bridge walls.

COMPARATIVE COST OF BOILER SETTING REPAIRS WITH FIRE CLAY AND REFRACTORY CEMENT

For Side Walls—	Fire Clay	Cement
1000 brick at $80	$80.00	$80.00
500 lb. of clay at $20 per t	5.00	.....
500 lb. of cement at $4.25 per 100 lb	.....	21.25
Labor in tearing down and rebuilding walls	40.00	40.00
Total cost	$125.00	$141.25
Life of job	5 mo.	12 mo.
Annual cost per boiler	300.00	141.25
Annual saving per boiler	.....	158.75
For Bridge Walls—		
500 fire brick at $80 per M	40.00	40.00
250 lb. fire clay	2.50	.....
250 lb. cement	.....	10.63
Labor, wrecking and rebuilding	20.00	20.00
Total cost	$62.50	$70.63
Life of job	6 mo.	4 yr.
Annual cost per boiler	125.00	17.66
Annual saving per boiler	.....	107.35
Total annual saving per boiler	.....	266.09
Total annual saving per 6 boilers	.....	1,596.54
Percentage reduction in cost	.....	63

Effectiveness of the bond between cement and brick is evidenced by the removal of old sections of wall in chunks, not in single bricks. Removing clinkers by slice bars does not loosen the brick.

When repairs are needed, the boiler is taken out of service Friday night, if possible, the setting allowed to cool and work started as soon as the temperature permits of men working on it. Ordinarily the unit is back on the line Monday morning, which allows only a few hours for the new work to dry before bringing the boiler up to pressure. This is done because demand is about up to present capacity. That the cement does not vitrify below 1450 deg. F. assists in allowing the brick sufficient movement to reduce expansion strains in the setting before the cement hardens, thus adding to the life of the walls.

Comparative costs for fire clay and cement are shown in the table. Brick used and labor will be the same in either case. Although two sizes of boilers are in use, it is found that the average repair job is the same for either size. Since 1926, when bridge walls were laid in cement, no repairs have been needed but a life of 4 yr. has been assumed as a conservative figure. Increase in durability of repairs has obviously made the use of cement, even at the somewhat higher cost, a good investment.

*From a report by D. E. Badger, Chief Engineer, Cambridge (Mass.) Electric Light Co.

Compressed Air for Power Plant Uses

SOOT BLOWING, TUBE CLEANING, DUST REMOVAL, ICE PREVENTION, PILOT VALVE OPERATION

SOOT BLOWERS may be operated by air as well as by steam. Two prominent plants, Stanton and Columbia, have this system installed and find it to work satisfactory. These plants are similar in the size of boiler units and in the pressures under which they operate, Stanton boilers having 17,962 sq. ft. of heating surface and operating at 625 lb. pressure while the Columbia boilers have 15,110 sq. ft. of heating surface and operate at 650 lb. pressure.

At the Columbia plant three compressors, each having a capacity of 1130 cu. ft. per min., supply air at 100 lb. pressure to the soot blowers. Two 1000-cu. ft. capacity tanks are used for storage. Each side of the boilers is equipped with 13 elements and each economizer with 12 elements. A tabulation of the data concerning these elements is given in Fig. 1.

To blow soot on a complete unit, approximately 116,000 cu. ft. of air are required. The total elapsed time for blowing a unit is 60 min. giving an average flow of 1935 cu. ft. of air per minute. The power required by the compressors during the blowing of one boiler and economizer unit is 386 kw-hr. Test results show that the same results can be obtained by blowing the first pass soot blower elements only on two of the operating shifts and the complete boiler on the third shift as can be obtained by blowing the complete unit on each operating shift. With this method of operating the elements, 4100 kw-hr. are used daily for soot blowing on boilers, which is about 0.24 per cent of the total power generated.

BOILER

Elements per Boiler	Size, In.	Orifices No.—In.	Rate of Air Flow, c.f.m.	Pressures, Lb. per Sq. In.	
				At Compressor	At Head
8	1⅞	18—¼	1050	95	87
8	1⅞	36—¼	1380	95	86
10	2	36—¼	1820	95	82

ECONOMIZERS

Elements per Boiler	Size, In.	Orifices No.—In.	Rate of Air Flow, c.f.m.	Pressures, Lb. per Sq. In.	
				At Compressor	At Head
8	2	23—¼	1420	95	83
4	2	36—¼	2460	95	75

FIG. 1. AIR SOOT BLOWER DATA FROM COLUMBIA POWER CO. PLANT

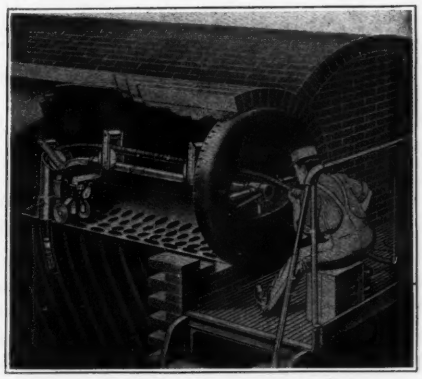


FIG. 2. AIR OPERATION OF BOILER TUBE CLEANERS

FIG. 6. PILOT VALVE ASSEMBLY FOR STACK DAMPER CONTROL

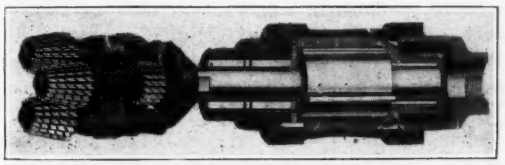


FIG. 3. AIR-DRIVEN TUBE CLEANER HEAD

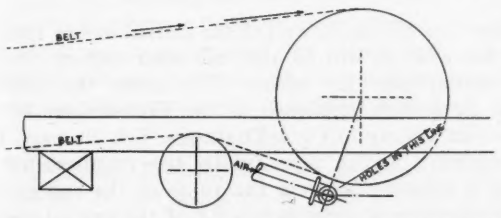


FIG. 4. AIR-CLEANING FOR CONVEYOR BELT

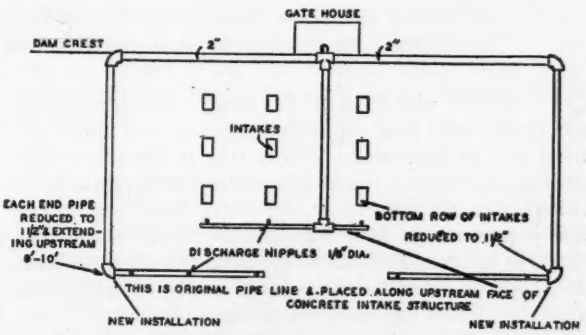

GATE HOUSE
DAM CREST
2"
2"
INTAKES
EACH END PIPE REDUCED TO 1½" & EXTENDING UPSTREAM 8'-10'
BOTTOM ROW OF INTAKES REDUCED TO 1½"
DISCHARGE NIPPLES 1⅛" DIA.
THIS IS ORIGINAL PIPE LINE & PLACED ALONG UPSTREAM FACE OF CONCRETE INTAKE STRUCTURE
NEW INSTALLATION
NEW INSTALLATION

FIG. 5. INTAKE OF HYDRO PLANT CLEANED OF ICE AND TRASH BY AIR

Cost of soot-blower maintenance per ton of coal fired is as follows:

Maintenance labor	0.475 cents per t.
Maintenance material	0.115 cents per t.
Total	0.590 cents per t.

AIR-OPERATED BOILER TUBE CLEANERS

Boiler tube cleaners operated by compressed air are used as illustrated in Fig. 2 and the construction of the tube cleaner is shown in Fig. 3. Consumption of

air at 80 lb. pressure is 65 to 95 cu. ft. per min. Larger tube cleaners use 115 cu. ft. per min. at 80 to 100 lb. pressure, increasing the power and speed 10 to 15 per cent. From ¾ to 2 hp. is required to operate one of these tube cleaners. Similar but smaller tube cleaners are used for condenser tubes. Water is used in combination with air in some cases to wash away the material which has been removed from the tube. It also keeps the tube cleaner cool.

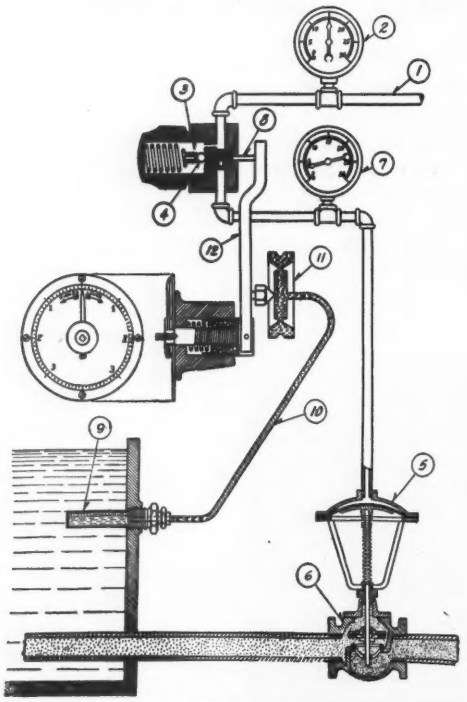


FIG. 7. AIR SYSTEM FOR PILOT CONTROL OF TANK TEMPERATURE

Blowing guns are used to clean generator windings, and to remove dust from conveyor belts, Fig. 4. Sandblasting by compressed air is used for cleaning stone work, for imprinting lettering and designs on stone and for roughening concrete surfaces. Pressures used for this purpose range from 60 to 85 lb. per sq. in. and small nozzles of about ⅛ in. diameter generally are used for these purposes.

Compressed air is used in ice plants to produce clear ice by avoiding entrapment of air through agitation of the water during the freezing process. It is employed in preventing ice formation along spillway flashboards at hydroelectric power plants and for safeguarding such stations from the hampering effects of ice during the winter and fine trash at all times as shown in Fig. 5.

Pilot Valves Control Combustion

Stack dampers and furnace atmosphere are controlled by valves controlled by pilot valves as shown in Fig. 6. Where the pilot valve cannot be attached to the main valve grouping, pilot valves are assembled into the control unit.

Pilot control is so sensitive and accurate in one system applied to unloading regulation of air compressors that for normal operation of standard equipment, a differential of 5 to 7 lb. may be maintained. Special equipments cover ranges from 10 to 35, to 75 and 75 to 125 lb. Application of pilot control to regulation of liquid temperature in a tank in which a direct single service controller acts in conjunction with a direct-acting diaphram motor valve is shown in Fig. 7.

Design of Pipelines for Hydroelectric Plants

To Secure the Most Economical Design of Pipeline for a Given Condition, Diameter and Thickness Are Figured by a Modification of Enger's Formula. By John S. Carpenter

SO MUCH money may be spent on hydroelectric plants with long pipelines that they will never pay a red cent as dividends. This is true to the extent that several such plants have sometimes bankrupted their owners. In the case of a new plant, therefore, it evidently pays to go into considerable detail to find out just how much money can be spent on the pipeline, what the power is worth when you are ready to sell it and what the annual expenses are going to be.

Thus one must balance losses and gains and determine at just what point he must stop. Fortunately there is some latitude in the choice and one need not bother himself about making diameters in fractions of an inch.

In general, a pipeline is designed with greatest overall economy when the annual interest and depreciation plus the annual value of the power lost in overcoming friction is a minimum. With a given plant, a pipe of small diameter will show a small annual cost for interest and depreciation but the value of the power used up in friction, which might otherwise be sold, will be high. With a pipe of large diameter, a small annual cost in friction loss will be shown but the annual cost of interest and depreciation will be high, all other factors remaining substantially the same. Thus arose the theorem of A. L. Adams, published in the Transactions of the American Society of Civil Engineers, Vol. 59, page 177, as follows: "That pipe fulfills the requirements of greatest economy wherein the value of the energy lost in frictional resistances equals 0.4 of the annual cost of the pipeline."

This applies to steel pipe, such as is commonly used for pipelines, and not to cast iron nor wood-stove pipe.

Modification of Enger's Formula

Several formulas have been developed to give the correct diameter for the assumptions made, depending upon the particular phase of the problem that was being investigated; for example, a pipeline for oil, a pipeline for waterworks use, and so on. The writer has used a formula originally developed by Professor Melville Enger with good results. For water power plants, the writer has reduced to simple terms an otherwise in-

volved formula involving a sixth root. Professor Enger's original article was published in Engineering Record, September 14, 1914, Vol. 70, No. 11, page 300.

The nomenclature used herein is the same as that used in the original article by Prof. Enger, as follows:

Let d = economic diameter of pipeline in inches
E = overall efficiency of the turbine and generator, in per cent
b = annual value of 1 hp. in dollars
Q = cubic feet of water per second
Z = hours per day that Q second feet flows
a = cost of steel in dollars per lb.
r = rate of interest plus depreciation, in per cent
t = minimum thickness of pipe in inches
c = coefficient in the Chezy formula
n = overweight due to laps, etc., on pipe material

The value of d can then be found from the following formula, which is No. 4 in the original article:

$$d = 3.91 \sqrt[6]{[E\,b\,Q^3\,Z] \div [a\,r\,t\,c^2\,(1+n)]}$$

This is rather awkward for quick solution by the slide rule but can be reduced down so it involves only a simple square root.

Selecting Values for Substitution

The value of E in most plants will not often be more than 75; in many cases, 70 will be nearer right. This is the product of the generator efficiency times the turbine efficiency. The value of one horsepower per year, b, may be taken at $20 and really is what the power can be produced for by the use of a steam or internal combustion engine. When erection costs are fairly normal, a is not more than 9 or 10 cents (to be expressed as 0.09 or 0.10) in place and for the steel itself 7 cents is a fairly representative value. Interest plus depreciation can be safely assumed as 10 per cent. The minimum thickness t, which is of course at the dam or forebay, may be assumed as 0.125 in. for diameters up to 24 in. and 0.1875 in. up to 40 in. diameter. The Chezy coefficient c may be taken at 100. The overweight due to rivets and lapjoints will usually average as 12 per cent, making the value (1 + n) equal 1.12.

Let us first take a 24-hr. plant which may be said to represent the typical plant for mines and railways. Inserting the above values, we are somewhat surprised to see the above heavyweight formula shrink to

$$d = 7.05 \sqrt{Q}$$

The famous Jawbone Siphon was to have a capacity of 430 cu. ft. per sec. and, of course, required an extremely large pipe, for which the foregoing assumption of t as 0.125 in. is not correct. After a first trial, we can judge better what t is to be and then correct our diameter. Inserting the values in the formula just given, we find that the resulting diameter is 146 in. Seeing from Enger's formula (4) that the diameter varies, inversely, as the sixth root of the plate thickness, we find that the correction is easily made. A pipe of anything near 146 in. diameter should not be less than 0.375 in. thick, which gives

$$(0.125 \div 0.375)^{0.166} \times 146 = 123 \text{ in.}$$

The actual diameter was 120 in., showing the close agreement with an actual job on which considerable economic work was done. The difference of 3 in. is due to other assumptions, probably in the overall efficiency, the annual value of the power and the cost of the steel.

If we take Z as 10 hr. per day, which would be more nearly typical of factory loads, we get

$$d = 5.27 \sqrt{Q}$$

It will be noticed that Q was taken as constant. This is open to some question and, for a new plant, the load curve of which is not known, it is wise to take it as constant until more data are available. A procedure that should be satisfactory is to take the expected load curve expressed in terms of Q and time in hours and find the mean Q. This value should then be used in the appropriate formula; that is, the 24-hr. formula.

Adjusting Diameter in Relation to Length

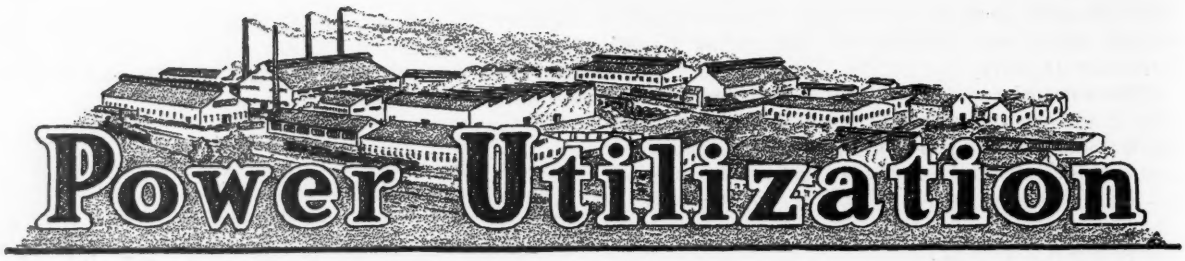
Using the value of d as found from either of the formulas, designate that as the diameter at the dam or forebay. As the pipe goes downhill, evidently heavier plate will be required to stand the pressure. The diameter must then be corrected for the plate thickness in the same manner as in the example illustrating correction for the Jawbone Siphon. Then proceed in the same way for each plate thickness down to the end of the line.

This method gives a pipeline of minimum weight. The diameters of the pipe so found will be seen to vary somewhat and, after a tabulation has been made showing the lengths and thicknesses of each section, the diameters can be finally adjusted so the pipe can be shipped nested (that is, sections telescoped within other sections) so that the room required for shipment is reduced to a minimum. The variation required for nesting will vary somewhat, depending on the thickness of plate and the style of riveting. For small pipe, as little as 2-in. variation in diameter will allow sections to be inserted within each other and thus will enable minimum carload weights to be secured, reducing the freight charges. Larger pipe and heavier plate will sometimes require as much as 4-in. variation.

It is interesting to compare the weight of a pipeline so made with the weight of one of uniform diameter. The writer has found that there is usually some 5 to 7 per cent less weight in favor of the pipeline of variable diameter.

Scrap cable of the lead covered variety is perhaps the most valuable item of junk handled by electric utilities. Salvage methods should be given careful consideration as disposal methods depend largely upon the quantity handled. Small quantities are usually sold upon the copper and lead content estimated from samples with sealed ends and joints excluded. Mechanical separation by chisel and hammer or rotary knives is sometimes accomplished but it is difficult and mechanical equipment is expensive. Perhaps the most satisfactory method is the reduction of the cable in a furnace. Low cost, quick handling and elimination of insulation are advantages. The lead can be cast in pigs and the annealed copper baled so as to command the best price. It is worth while separating the seals on the end of the cables because of the tin content, which makes it more valuable.

Spreading fresh coal on the fire cools the furnace.



Electric Current Distribution

By O. H. Henschel

In plans covering no little amount of floor space and where, therefore, energy must of necessity be carried comparatively great distances, excessive voltage drops may be encountered. In order to compensate for this, many installations are designed for 440 to 480-v. distribution but even such voltage does not always prove satisfactory.

Recourse must then be taken to still higher voltage at least for primary distribution. Such a system is schematically illustrated in Fig. 1.

Energy may be purchased at a primary voltage of, let us assume, 13,200 v. and stepped down to 2300 v. by means of a transformer or a bank of transformers of proper capacity or, where local generation proves the more economical 2300 v. may be provided directly from the generating plant.

In the case shown, three 2300-v. mains deliver energy to each of the plant bays where transformers are installed for stepping down to 480 to 240 v., as may be desired or required. These units, together with auxiliary secondary distribution boards should always be housed within properly ventilated and drained fireproof housing. In other words, the whole should constitute what may be well termed a secondary sub-station.

Secondary Distribution

Usually the secondary distribution system is of the combined multiple main and tree types although, by use of the suggested disconnect switches, the ring system may or may not be brought into play. Obviously, this would be dependent upon the volume of secondary distribution board switching being employed at any given time.

Under ordinary conditions of operation, transformers Nos. 1, 2 and 3 would undoubtedly be employed to serve buildings Nos. 1, 2 and 3, respectively through distribution boards Nos. 1, 2 and 3. Should, however, an oil switch failure occur on distribution board No. 1, the system of building No. 1 could well be kept alive without interruption by the closing of disconnect switches Nos. 1 and 2. In a similar manner feeder A may be entirely isolated from transformer No. 1 and

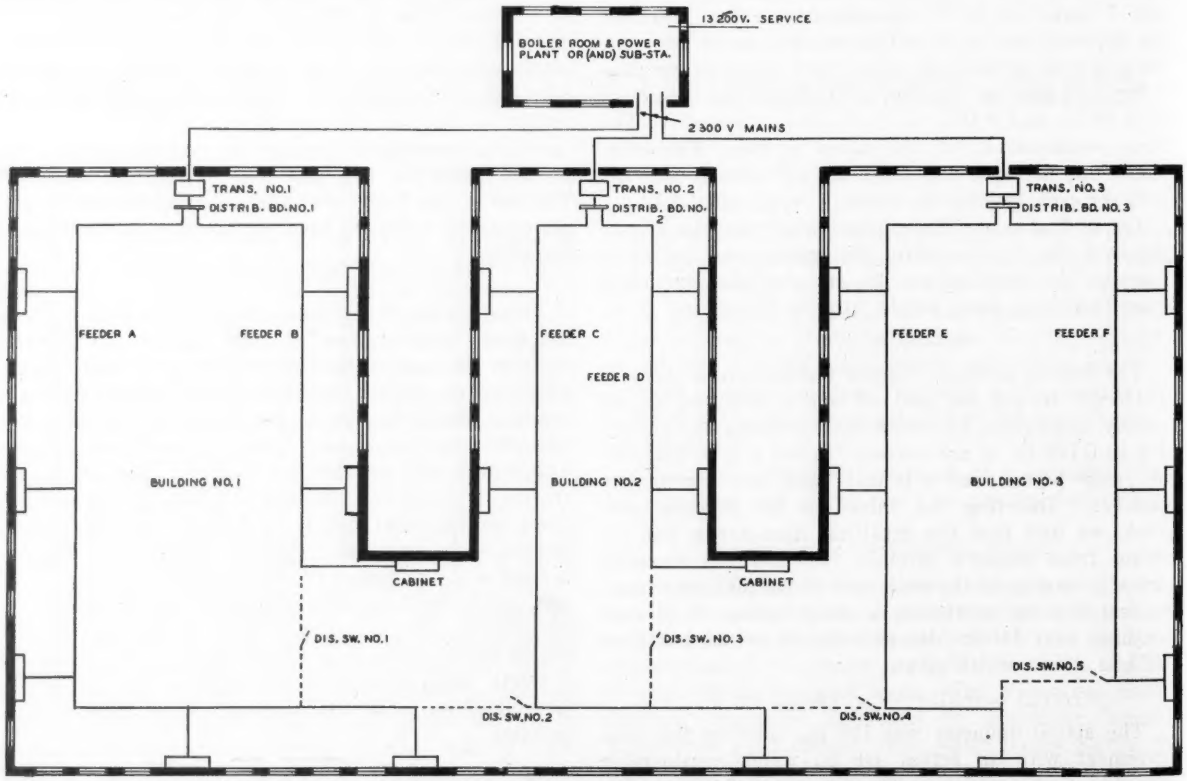


FIG. 1. INDUSTRIAL PLANT SYSTEM EMPLOYING HIGH-VOLTAGE PRIMARY DISTRIBUTION

be served by transformer No. 2 by the closing of disconnect switch No. 2, disconnect switch No. 1 being open. Or, in the event of failure of transformer No. 1, both feeders A and B could well be served, by the throwing in of disconnect switches Nos. 1 and 2, by transformer No. 2, or by both transformers Nos. 2 and 3 by the additional closing of disconnect switch No. 4.

In general, the scheme presented is one of greatest flexibility. All or any parts of the system may be readily kept at least alive by two or even by any one transformer.

Typical Ring System

Distribution cabinets or switch banks are eliminated in a ring system recently developed and in use in some of the larger and more modern plants. The arrangement is schematically shown in Fig. 2.

Mains are carried in metal ducts equipped with conveniently placed outlets from which point taps connect to combined safety disconnect switches and remotely controlled starters. These are placed in close proximity to the mains, although the motors themselves may be at some distance. Convenience, flexibility and economy of copper are the advantages claimed for this scheme. The arrangement is particularly well adapted to plants in which units or departments may be shifted from time to time.

For emergency or otherwise this system may at any time, by means of the indicated disconnect switch be connected into a parallel main-tree system.

A typical installation of grouped combination safety switches and starters is illustrated in Fig. 3.

Unless use be made of the ring system with practically direct tie into combined disconnect switch and starter, actual distribution must be made through either

FIG. 3. COMBINATION SWITCHES AND REMOTE CONTROL STARTERS

a regulation cabinet or a bank of safety switches. Obviously, under the assumption that ample feeder and main switch capacity has been provided, the latter will perhaps prove the more desirable from the standpoint of greater convenience and flexibility. Added switches can at all times be installed, thus removing the limitations of the regulation cabinet.

Comparison of costs may be made by citation of a typical case at hand. Eight 30-amp. feeders were required installed. With the regulation cabinet the following estimated costs were involved.

(1) Power panel and cabinet consisting of 1-in. slate panels having 200 amp., 440-v., 3-wire main lugs only feeding eight (8) 30-amp., 440-v., three-pole, single throw fusible knife

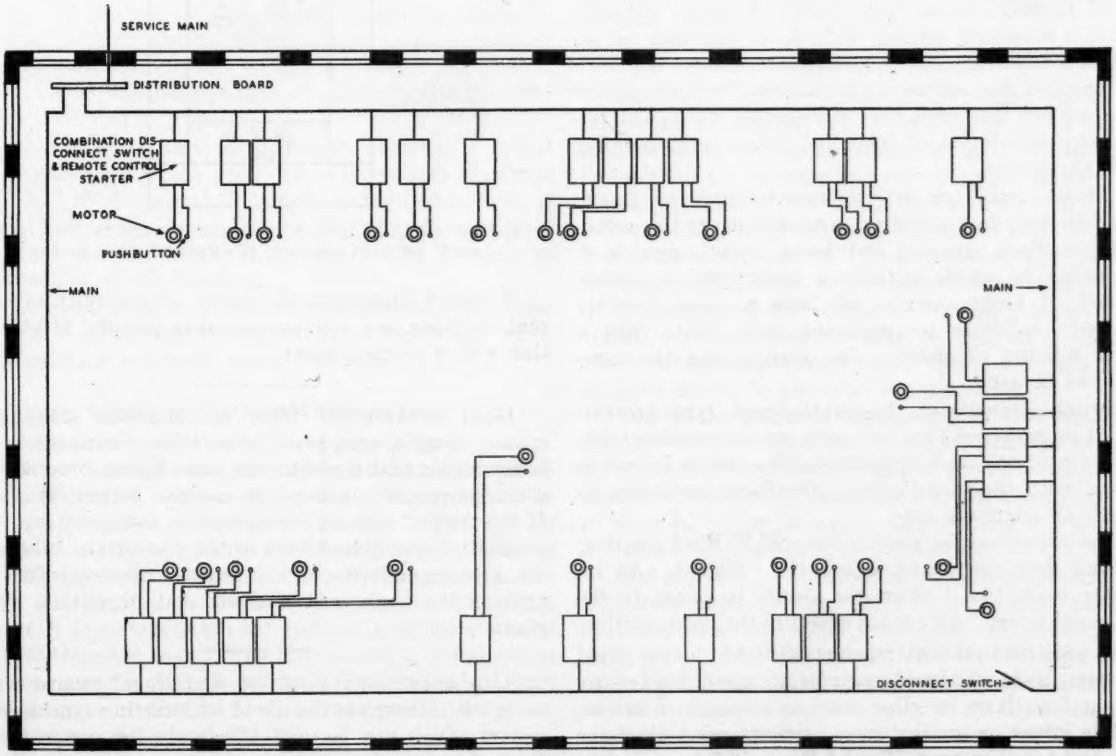


FIG. 2. RING SYSTEM WITH NO DISTRIBUTION CABINETS OR SWITCH BANKS

	switches. Cabinet for surface mounting to be of code gage steel with 5-in. rear wiring pocket, removable side plates and double doors equipped with directory plate, vault handle and Yale lock	$92.00
(1)	200-amp., 440-v., three-pole unfused, single-throw safety switch	16.00
	Labor for installation but not including running of feeders	15.00
	Total	$123.00

On the other hand, for the switch bank we would undoubtedly encounter the following costs:

(8)	30-amp., 440-v., three-pole, fused, single-throw safety switches at $6.00 each	$48.00
(1)	200-amp., 440-v., three-pole, unfused, single-throw safety switch	16.00
(1)	Wiring gutter	25.00
	Wiring	7.35
	Backing, supports, etc	15.00
	Labor for installation but not including running of feeders	30.00
	Total	$141.35

It appears possible, then, to enumerate the advantages of the cabinet installation as: Lower cost; Greater compactness allowing installation with smaller space; More pleasing appearance.

Advantages of the switch bank installation are: Greater convenience; Increased flexibility; Higher degree of safety.

Flexible Safety Panels

Of recent development is a convertible safety panel as illustrated in Figs. 4 and 5. The panel board is made up of interchangeable units mounted upon channels within a standard cabinet with buses mounted in an isolated compartment in the rear of the units. Circuits are provided for individual units, with fuse mountings upon a fixed base such that circulation of air and the necessary ventilation of fuses and the current-carrying parts are insured.

Circuit units are interchangeable with all buses. Unit sizes vary in dimensions in proportion to the capacity of the fuses provided and, being interchangeable, it is possible to install initially a panel with a certain number of large circuits yet later to meet possible changed conditions by replacing these units with a larger number of smaller size, maintaining the same total bus capacity.

Switch elements of the double-break type are employed, so arranged that live parts are inaccessible when the cover of the unit is opened. The switch proper is opened with the door, leaving the fuses accessible although all parts are dead.

The switch can be readily changed to dead position, the unit door closed and sealed, if so desired. An indicator reads "on" when the switch is closed in the live position and "off" when closed in the dead position.

In addition to the interchangeability of units in panel interiors, each unit itself provides a convertible feature so that fuse jaws, or clips, may be changed to accommodate larger or smaller fuses, without removal of the unit and to allow conversion of the unit from one voltage to another. Naturally, all spacings are made adequate for maximum voltage.

All switches are provided with high-pressure contacts and, on circuits of 400 amp. and more, fuse jaws are of the positive pressure type.

A positive latch with convenient lock on and lock off features is employed.

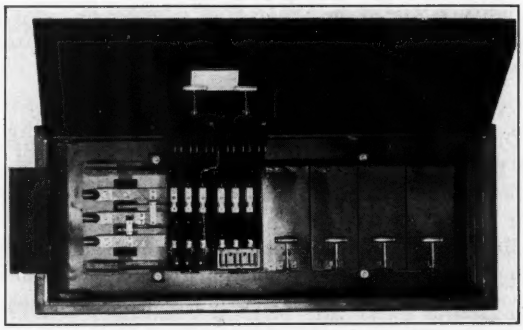


FIG. 4. UNIT SECTIONS OPENED AND CLOSED WITH BUS BARS BEHIND THEM IN CONVERTIBLE PANEL

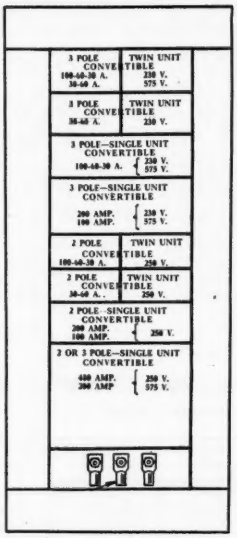

3 POLE CONVERTIBLE 100-60-30 A. 30-60 A.
TWIN UNIT CONVERTIBLE 230 V. 575 V.
3 POLE CONVERTIBLE 30-60 A.
TWIN UNIT CONVERTIBLE 230 V.
3 POLE—SINGLE UNIT CONVERTIBLE 100-60-30 A.
230 V. 575 V.
3 POLE—SINGLE UNIT CONVERTIBLE 200 AMP. 100 AMP.
230 V. 575 V.
2 POLE CONVERTIBLE 100-60-30 A.
TWIN UNIT CONVERTIBLE 250 V.
2 POLE CONVERTIBLE 30-60 A.
TWIN UNIT CONVERTIBLE 250 V.
2 POLE—SINGLE UNIT CONVERTIBLE 200 AMP. 100 AMP.
250 V.
2 OR 3 POLE—SINGLE UNIT CONVERTIBLE 400 AMP. 200 AMP
250 V. 575 V.

FIG. 5. POSSIBLE ARRANGEMENTS OF UNITS FOR VOLTAGE AND CURRENT IN FLEXIBLE PANEL

Figure 5 illustrates the degree of flexibility of current carrying and voltage capacities possible of utilization with a single cabinet.

Good lubrication from an economic standpoint means: longer equipment life; lower lubricant cost; lower repair and maintenance cost; higher production; a cleaner product; lower unit cost and higher efficiency. If the cost of repairs, replacements, lost time and lost production could be added to the cost of the lubricant the average mill would soon see the necessity for improving the haphazard methods that prevail in many plants.

Low starting torques of centrifugal pumps make them well adapted to the use of self-starting synchronous motors which can be used effectively for power factor correction.

Electric Motor Operation and Maintenance

METHODS OF PROCEDURE IN DETERMINING CONDITION OF MACHINES, INSTRUMENTS USED. OVERHAULING AND REPAIR.

RIGHTLY APPLIED, the direct-current motor has high efficiency, especially on varying loads when carried by a series-wound motor. Inspection of the direct-current motor must be rigid and frequent, if service is severe, especially in dusty or damp locations. Where there is neither dust nor dampness, it will give good service. Generally there is plenty of air gap so there trouble will seldom occur with bearings except with railway motors, which, if not carefully watched, may drag on the poles. Brush mechanism should be checked carefully and the commutator examined for rough spots and high mica. Rough spots can usually be taken out with a grinding stone, unless the pitting is quite severe, and high mica can likewise be ground down but, if high mica presists, it is better to undercut the mica and keep it slightly below the surface of the commutator bars.

On these as well as all other motors, bearing wear should of course be checked and, when it becomes serious, bearings should be replaced or rebabbited.

For all types of motors, the frame bolts and fastening bolts should be checked for tightening occasionally but usually this need be done no oftener than once a month.

BELTS AND COUPLINGS

Couplings on direct coupled units should be checked for alinement and to see whether any of the bolts are loose. If flexible or semi-flexible units are used, the flexible portion should be examined occasionally and some record made of its condition. Gears and pulleys are to be checked for looseness on the shaft, also gears for worn teeth and alinement.

Alinement of belts is important because, if a belt runs partially off the pulley, it will produce abnormal pull and vibration and, if it rubs on the bearing box, it may burn up the belt, possibly set fire to the pulley if of paper and in one case it has been known to result in destruction of the building.

Lubrication of gears and couplings should of course be given attention at regular intervals since, when lubrication is neglected, power bills rise.

CHECKING CURRENT CONSUMPTION

Some troubles cannot be found merely by inspection. These are usually made evident by heating, blowing of fuses, arcing of brushes on direct-current machines or similar symptoms. Usually when these appear, if an ammeter is connected into the circuit, it will show an abnormally large reading. In a direct-current motor only one reading is necessary but, in a three-phase motor, it is necessary to read current in all three phases and, if these are found to be unbalanced, it is indication of some trouble with the motor. Each individual part will have to be checked to find what part is defective, as there may be several defects.

Nearly all trouble either mechanical or electrical will show up on an ammeter reading, which indicates, of course, that too much power is being used. Check the reading of the ammeter against the current that the motor is supposed to use as shown on the nameplate. If the current reading is too high, there is a cause and unless this is removed it will show up on the power bill. It is well to make a current test of each motor at least once a month and, for motors that are used steadily in severe service, such tests may well be made oftener.

INSULATION RESISTANCE TESTS

At intervals and in any case where abnormal motor action is encountered, it is well to test out the insulation resistance. This is sometimes done by a magneto but larger plants usually have meggers or megohm testers which give better indication than a magneto. The megger will often indicate a defective machine when a magneto will give no indication at all. By comparison of megger readings, the time when overhaul of a motor is necessary will often be detected.

Voltage for which a machine is designed has much to do with the standards set for megger readings; size and location also influence the resistance needed. Whenever overhauling a motor, it is well to give it the megger test especially if the insulation seems brittle and dry. If the reading is low, it is generally wise to rewind the machine and it is better, if possible without hindering production too much, to do this rewinding before the machine has actually burned out.

INSTRUMENTS NEEDED

Besides the megger, instruments needed are an ammeter and a voltmeter for alternating or direct current or both, according to the motors in use, and with range suitable for the voltages and currents used in the plant. There is available for voltage measurement an a.c.-d.c. model reading from 150 to 600 volts. If 2200 or higher voltage is used, a potential transformer may be used with ratio sufficient to bring the secondary voltage within the reading of the voltmeter. A clamp type current transformer and ammeter may be had which forms a handy alternating-current unit. Also a test light and a magneto should be provided for snap tests.

Test of the motors is unnecessary at each weekly inspection but a monthly test is a good plan for grounds, short circuits open circuits and in any case, such a test should be made every three months. If records are kept of these tests, any change in operation of the machines for better or worse will be noticeable.

If a motor is found operating at light load most of the time, it is better to exchange it for some other motor in the plant which may show overloaded. Generally, where there are a number of motors, such an exchange can be made with little trouble and the lightly loaded machine will be running at poor efficiency at all times, while the overloaded machine will deteriorate too rapidly. Where examination shows that a motor is overloaded, even

though it is sufficiently large to drive the machine, it is time to overhaul the machine itself as the trouble is usually there and not in the motor. I have found that many calls for the electrician should really have been for a machinist but it is usually necessary for the electrician to prove this.

Overhauling a Motor

For overhauling, motors should be removed from service, taken apart and carefully tested for all defects which can be possibly imagined. These will include grounds, short circuits, open circuits, resistance of insulation, condition of commutator and brushes, looseness of windings or connections and, in fact, every possible thing which might interfere with first rate operation. As a rule, it is better to make repairs at some stated interval but, in case of emergency, a motor may have to be removed from service and overhauled promptly.

Mechanical Faults

Any worn bearing should be replaced, or rebabbited if of large size; small motors should be examined for rotor clearance before taking down and if new bearings are needed they should be installed. Roller bearings of the tapered type are generally furnishd with shims so that the rotor can be centered without removing the bearing. Before making bearings for a sleeve type motor, it is best to swing the rotor in a lathe and check the shaft and core for true running. Also see whether there is any looseness between shaft and core which often happens in gear driven machines.

If the shaft is found to be loose, it should be replaced and to do this, the shaft must be taken out of the core, the shaft trued up on the outside and the bore of the core trued on the inside. The shaft is usually a press fit to the bore and, if much turning is necessary a new shaft may be required, although in some cases a bushing may be used. If the shaft is bent, it must be straightened or better a new one made, as it is seldom possible to straighten the shaft of a large motor. After shaft and core are running true, it is time to make new bearings. If the shaft is out of round or pitted, it will be necessary to turn or grind true where it runs in the bearing. If a keyway is ragged it is a good idea to weld in a piece, turn that off and cut a new keyway in some other location.

Winding Repairs

If the armature is not to be removed, it is wise to take a light cut on the commutator while it is in the lathe as this will insure its being true when returned to the motor. If the armature has to be rewound, the shaft and core should be checked and the commutator turned after the winding has been put on, dipped and baked, or painted. A squirrel cage rotor should be checked and, if any bars are found loose or broken, they should be brazed or in some cases resoldered. If brazed, the rotor should be placed in a lathe and bars turned down below the rotor lamination. It is well to observe whether the commutator mica has been undercut and if so, it should be redressed. In case it was not undercut, sometimes it will give better service, if that operation is performed.

For the stator of an alternating-current motor which does not need rewinding, the windings should be blown out and thoroughly cleaned with benzine or gasoline of the straight gas type then dried with air of low velocity. If the machine is damp, it should be baked first of all then, if it stands a megger test, it should be given a good coat of baking varnish or sprayed with a good grade of air-dry insulating varnish. Where motors are rewound, insulation the same as that on the original winding for the operating voltage used should be applied.

For direct-current motors, the field coils should be tested for grounds, open circuits, and examined to see whether they have been heated. If insulation is frayed, coils should be removed from the frame and reinsulated. After fields are replaced, the whole should be sprayed with black insulating varnish. It is best also to test the fields for shorts between series and shunt windings.

Oiling System

When overhauling, oil gages should be inspected and if broken repaired, also missing covers, replaced. The lids to all oil ring inspection cavities should be replaced and felts renewed. End caps for the end belts should be replaced, if gone, and any felts around shafts at the bearings should be renewed at this time. Brushes and brush holders should come in for repairs and, wherever needed, parts should be renewed. If not in stock these should be ordered and placed on the machine as soon as they arrive. Be sure that oil rings on ring oil bearings revolve freely.

After the machine overhauling is completed, the machine should be painted some color which will show dirt easily; in bakeries or similar locations this will be white but in any case it is better to have the dirt show so that the motor will be kept clean.

Some Plant Experiences

Examples of what happened in some plants will illustrate the value of simple meters. At a stone working plant a 15-hp., 220-v., 3-phase alternating motor when pulling its load would get hot and was seen by the operator to smoke. This motor was connected to its load, a stone planer, by chain drive. The rear bearing was worn so that it almost let the rotor rub on the stator. A new bearing was made and the motor replaced in service. It would do the work but would groan like a wounded animal on the reversed stroke which was made at high speed and is the real load on all planers. Putting an ammeter in circuit and a voltmeter across the mains, showed that the voltage was at full 220 and that the motor had its load all the time but on the reverse the ammeter would swing to 65 amp., then drop to about 55 to 60 for the rest of the return stroke. On the cut the current was around 40 amp. When questioned, the man in charge admitted that the machine had been overhauled the day before and examination showed a cut bearing on the jackshaft of the return mechanism.

In a bottling plant, a 15-hp., 3-phase motor would run a pump empty but, as soon as load was applied, the motor would stall and pull out. Owner and electrician were thoroughly disgusted with the whole situation. As all needed repairs had been made, there seemed nothing to do in that direction but the ammeter showed abnormal current. We suggested a voltmeter, which no one had thought to use but which should always be used in connection with an ammeter test, as one reading is

supplemented by the other. No voltmeter was handy, but we did have a 220-v. lamp and a socket. With the motor shut down, we had a good light and found later that the voltage was about 210 v. With the lamp across the main when the motor was started, the light could just be seen. Also, when the motor was up to speed, the light would brighten up some but, when load was applied, it would almost go out again. With an instrument from the power company it was later ascertained that the voltage when the motor was trying to run was 160 instead of 220 and the power company was kind enough to refund about $40 for overcharges on the bill during the last three months. The bill had risen after some transformer changes were made and, when the condition was rectified, the motor ran all right.

In another case, a direct-current, 230-v., 5-hp. motor was driving a skip hoist to raise sand to a mixer in a foundry. According to the manufacturer of the skip hoist, the motor was of ample size and, as the load was intermittent, it should be easy for the motor to carry the 7½ hp. for a short length of time. Although the operator condemned the motor, we were not so sure and connected an ammeter and voltmeter in the circuit. At full load, normal current was about 20 amp. but, when the skip was loaded and hoisted to the dump, the current rose steadily until, near the top, about 60 or 70 amp. were recorded. Going over the whole situation, it was found that, as the appropriation was very meager, a cast ring gear with a steel worm for the speed reducer was used instead of a bronze worm, which would operate at much higher speed and with less friction than one made of steel. Some other small mechanical changes had been made in the design of the machine and the whole result was the current was three times what it should have been. The point is that the simple test of the voltmeter and ammeter showed that the motor was being abused.

One case where the megger proved superior to the magneto was when a large power company informed a coal mining company that a telephone man had traced some interference to their substation and that when their power was cut it cleared the telephone lines. A magneto was secured and both motor generator sets were tested on, both a.c. and d.c. sides, also starting equipment. The magneto was a 35,000-ohm equipment and would seem able to indicate almost anything in reason. A drainage transformer on the telephone lines near the substation was destroyed and, when the generators were started up, the lightning arresters on the substation were destroyed. There surely was a ground somewhere. A megger was borrowed from the power company and it indicated zero in connection with resistance. The motor was given a potential test with its operating voltage and broke down in eight places. The coil insulation was so eaten that the slot was full of powdered mica and the insulation resembled a tree that has been eaten by wood borers. Incidentally, this machine was rewound in 12 hr., one new bearing was provided and the vibration of the machine entirely ceased.

Look Before Dismantling

Before starting to overhaul a motor, whether alternating or direct-current, it is well to make some sort of sketch showing how the leads are brought out, positions of front and rear heads, connection to terminals and the like. Front and rear heads should be marked on the heads and on the frame with punch marks. If the connections are complicated, it is a saving of time and no display of ignorance to make a rough sketch of the machine as it is. Of course, if the machine is connected wrong, that may make trouble but the chances are largely against that and, if the repair man knows the principles of the motor, he will probably catch any mistake when making the sketch. Especially on 3 and 4-speed, alternating-current motors, it is well to make a sketch so that the motor will not reverse in the field, that is the motor run in one direction on one winding and in another on the other, as this might be rather confusing. It can, of course, be remedied by reversing the proper wires.

When doing an overhaul job, it is best to do one thing at a time right, instead of trying to rush through and find, when the motor is tested, that half a dozen things are wrong.

Inspections carried out consistently and conscientiously, overhauls made at suitable intervals and reliable tests will always result in better utilization of power.

Electric Mule Hauls Cars

First Installation of A.C. Mule Car in Coal Dumper. By B. T. Green*

INTERESTING and unique application of an alternating-current motor equipment has just been made in connection with a Wellman mule haulage built for The Koppers Construction Co., for placing railroad cars

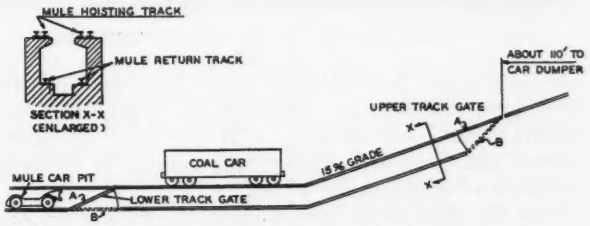


FIG. 1. THE MULE CAR AWAITS ITS PREY

on the cradle of a revolving car dumper. All previous installations of mule haulages have been operated either by direct current or the Ward-Leonard system of voltage control. In this case, as no direct current available, it was necessary to use alternating current exclusively, which involved some unusual problems.

Electrical equipment is unique in that it consists of a 500-hp. main motor, Fig. 2, operated from 2300-v., 3-phase, 60-cycle, with a two-speed torque motor operating at 440 v. to give the necessary slow-down features. The main and torque motors are direct connected through herringbone gearing to the mule haul drum as shown.

Two high torque 8-hp., squirrel cage motors automatically raise or lower the bypass gates which allow the mule to travel beneath the railroad track on the return cycle, Fig. 1, thereby allowing the loaded railway car to be placed in position for the mule to pick it up and place on the dumper cradle.

This electrical equipment operates the mule automatically as follows: Assuming that the gates are in

*Electrical Engineer, Wellman Engineering Co.

the raised position for the hoist cycle of the mule (position A of Fig. 1), the mule is brought out of the pit by the torque motor alone, running at its high speed, or 150 ft. per min. for the mule. At the proper point, the torque motor is decelerated to 50 ft. per minute to engage the railroad car by changing to the low-speed winding of the torque motor. At this time, the main motor is put on the line with all of the secondary resistance inserted. After the car has been engaged by the mule, the torque motor is taken off the line and the main motor automatically accelerated to full speed or 300 ft. per min. of the mule.

As the car approaches the car dumper the mule is slowed down by inserting resistance in the secondary of

FIG. 2. THIS WINDING PLANT WORKS THE MULE

the main motor and the torque motor is put on line with the high-speed winding. Thus the car is placed on the cradle of the car dumper at 150 ft. per min. The slow-downs and stops are automatically controlled by limit switches or by the master switch.

At the start of the return cycle, the track gates are lowered to position B, Fig. 1, and the main motor is run at full speed until the bottom slow-down is reached where the main motor is taken off the line, and the mule is driven to the final lower limit by the torque motor on the high-speed winding. As soon as the mule reaches the lower limit, the torque motor is cut off the line and the gates automatically start changing to the hoist position.

This mule haulage is fitted with General Electric motors and is designed for operating on a 15 per cent grade, placing 20 cars per hour on the dumper cradle, the maximum capacity of the cars being 320,000 lb. loaded weight.

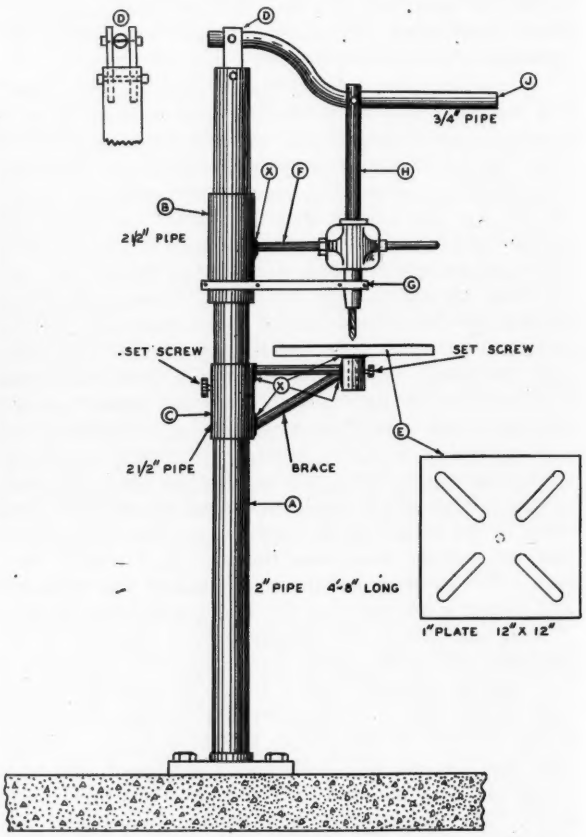
While this installation is for hauling coal cars, the method is obviously applicable to placing cars for any purpose and for other purposes in materials handling.

Stand for Portable Drill

RECENTLY a large number of holes were to be drilled in angle irons in a plant that was located at some distance from a machine shop and no drill press was available. One of the two portable drills in the plant was rigged up as shown in the sketch and proved successful for the job.

For the main part of the stand A, a piece of 2-in. pipe, 4 ft. 8 in. long, was screwed into a large casting which is turn was bolted to the floor. Part C which supports the table E is a 2½-in. pipe nipple 8 in. long. The table E a piece of 1-in. steel plate welded to a short piece of cold-rolled shafting, which allows the table to be revolved. The table can be raised or lowered by loosening the set screw in sleeve C.

Part B is also a piece of 2½-in. pipe, 10 in. long, which slides freely on the upright pipe A. Originally the two handles of the portable drill consisted of two



PORTABLE DRILL STAND MADE PRINCIPALLY OF PIPE AND FITTINGS

1-in. pipes hence, by removing one of these the drill could be screwed on pipe F, which is welded to the sleeve marked B, G is a ⅜ by 1½-in. strap iron to steady the drill and take some of the strain that would otherwise be thrown on F.

The breast plate of the drill was also removed and part H used in its place. This is a piece of pipe, split and drilled to allow the handle J to be inserted. D is made of two pieces of ⅜ by 1½-in. flat iron to give a flexible joint. All points marked X are welded. This stand allowed the work to progress rapidly and accurately, which would not have been the case, if we had tried to use the drill as a portable tool, held by hand.

Cold Spring, Minn. CHAS. A. PETERSON.

DIESEL PLANT designers sometimes go to extremes with air and lubrication oil filtering and overlook an important item in fuel filtering or centrifuging.

Feedwater Heater Rearrangement Improves Operation

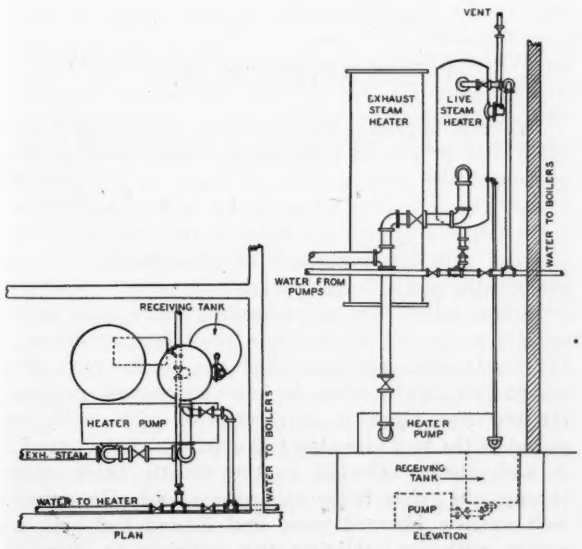
SINCE OUR PLANT was put into service about 15 yr. ago, the feedwater has been drawn from a common supply tank, the temperature of feed varying from 160 to 200 deg. F. Water from this tank was also used to wash and fill locomotives and the demand, sometimes, is heavy. This supply tank is equipped with an exhaust steam heater but owing to the difficulty of getting feed pumps to handle water much over 200 deg. in temperature, we have never been able to get much benefit from our exhaust.

Installation of a separate feedwater heater was considered but we could not see where it could be placed advantageously without entailing excessive expense in altering the piping layout. The buildings are heated by hot water under forced circulation and two heaters were installed, one, an exhaust-steam heater; the other, a high-pressure closed heater which has not been used for the past 3 yr., as the low-pressure heater furnished sufficient steam.

Authority was obtained to repipe this closed water heater for use as a feedwater heater and this was done, as shown, at a small expense, only a few minor piping changes being required and these were such that the heater could be reconverted easily to its original condition.

We reversed the connections so as to have water pass through the space originally meant for steam. The water from the feed pumps passes upward through the tubes and discharges at the top. With this arrangement we obtain a constant temperature at 210 deg. F. regardless of the temperature of the tank water. At present we carry no back pressure but later we will probably place a back-pressure valve in the vent line and carry from 2 to 4 lb. back pressure. As the whole system is tied together, a higher pressure may force the water out of the supply tank. A marked improvement in the steaming of our boiler has been noted since we made the change.

Mechanicville, N. Y. R. F. LEACH.

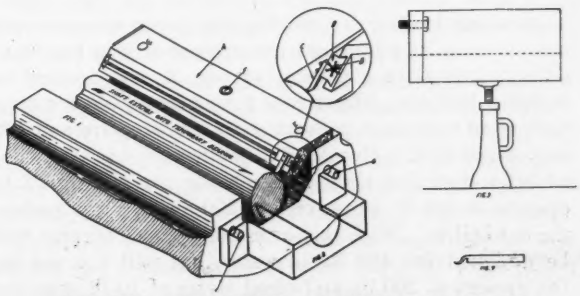


INSTALLATION AS CHANGED FOR OPERATION AS OPEN FEEDWATER HEATER

Re-turning a Main Bearing Journal

HAVING BEEN badly scored, it was decided to restore the main bearing journal of our direct-connected engine to good condition by re-turning it. As it would have been a difficult and costly job to remove the flywheel and rotor from the shaft and the shaft from the engine and send the latter to a shop having the necessary machinery to do the work, the turning was done in place.

Equipment for re-turning the shaft was made up of the device shown fastened at the top of one jaw of the main bearing, Fig. 1. The device was made of an angle-shaped casting which hung down toward the shaft and included a movable head B which carried the tool C and was fed by the star D which projected beyond the engine bed far enough that a pin screwed into the eccentric face would engage the star as the shaft turned and feed the head automatically.



TURNING ATTACHMENT PERMITS REPAIR OF CRANKSHAFT IN PLACE

Device A is held in place by the main bearing stud F and two auxiliary screws EE. A temporary bearing, Figs. 2 and 3, made of a cast-iron block, babbited on its bearing surface and supported by a heavy jack-screw, as shown in Fig. 3, was fastened to the side of the engine bed by bolts GG.

Power for turning the shaft was applied by means of a belt running from the flywheel to a jack shaft and thence to an electric motor. A roughing tool, as shown in Fig. 1, and a finishing tool with a spring lip, as shown in Fig. 4, were used. Much care was used in setting the device and after the shaft was finished it was hardly 0.002 in. out of truth. A little filing and application of emery cloth finished the job.

Burlington, Iowa. GUY EDWARDS.

Windowless Construction for Paper Mill

ONE OF THE INTERESTING features of a newsprint paper mill being built by the Blandin Paper Co. at Grand Rapids, Minn., is the absence of windows and the utilization of the ultra-violet rays from mercury vapor artificial lighting. This new building will house a new 156-in. newsprint machine.

Construction cost of this type of building is somewhat lower then for the ordinary type and there is some saving in heating, particularly in this northern climate; however, the chief advantage is that it is possible to maintain close control of the mill ventilation, an extremely important consideration in the manufacture of paper. Drying is one of the important factors both in cost of paper manufacture and the quality of the finished product. The absence of windows in the building makes it possible to have exact control of the air conditions in the machine and finishing rooms. Better working conditions are also anticipated as a constant circulation of fresh air is assured without annoying drafts.

Better lighting conditions can be secured by proper placing of the artificial lights so as to avoid annoying and dangerous shadows and variations of intensity, always present with natural lighting from windows. Over 100 Cooper-Hewitt mercury lamps are to be installed and in order to safeguard the health of the employees, these lamps will be fitted with the new Uviol tubes which radiate ultra-violet rays to approximate the healthful qualities of direct sunlight which is lost when it passes through ordinary window-glass. As a paper mill operates 24 hr. a day and artificial lighting is necessary during the daytime, even with ordinary construction, lighting costs will not be increased a great deal.

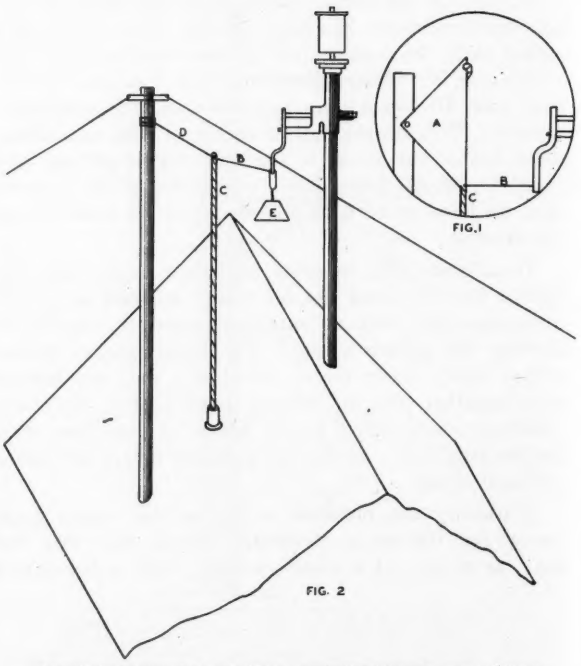
A steam turbine for driving the paper machine and the purchase of additional electric power was first considered, but after a careful survey, it was decided to install a 4000-kw., 80 per cent power factor bleeder type turbine to operate at present at 200 lb. pressure and 125 deg. superheat. Eventually another turbine will be added and at that time, a new boiler plant designed to operate at 425 lb. pressure and 250 deg. F. will replace the old boilers. With this in mind, the new turbine will be designed for 400 lb. pressure, but will operate for the present at 200 lb. and bleed steam at 10 lb. gage for drying. A 720-hp. synchronous motor will drive a d.c. generator to furnish power for driving the line shaft motor. Speed control will be secured by the Ward Leonard system. Progress was well under way the latter part of January and it is hoped to have the machine running by June.

A. J. KULL, Chief Engineer.

Blandin Paper Co.,
Grand Rapids, Minn.

Steam Whistle Experiences

SLOBBERING of a steam whistle due to entrained water caused by a leaky valve resulted in a laughable production of peculiar sounds until the proper tone was secured. The steam valve which controlled the whistle was located on top of the boiler at the lower end of about 20 ft. of 1½-in. pipe which led to the whistle above. Condensation filled the pipe and had to be blown out before the steam could reach the whistle.



STEAM WHISTLE VALVE CONNECTIONS TO AVOID CONDENSATION TROUBLES

Attempt to remedy the trouble by connecting a small drain pipe to a point immediately above the stop valve prevented the accumulation of water in the pipe but caused the steam to be admitted rather slowly when the valve was opened resulting in the production of a series of ridiculous sounds before the steam pressure at the whistle was sufficiently high to blow it properly.

Substitution of a quick-opening valve close to the whistle and about 10 ft. above the boiler, as shown in the illustration, was then tried and as the valve lever moved horizontally when the valve was opened or closed, the engineer rigged a pole made of pipe which was guyed to the roof and attached a pulley at the top of it. A sash cord connected to the whistle valve passed through the pulley to the boiler-room floor. This worked well until a blizzard came and loaded the cord and pulley with ice, obliging the engineer to blow the whistle from the top of a step ladder on the roof.

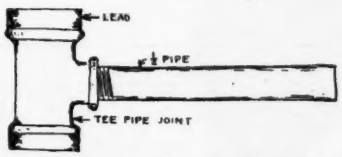
The pulley then was discarded, a bell-crank was attached to the pole and the bell-crank and whistle connected by a wire, B, as shown in Fig. 1. On two occasions, snow and sleet caused the bell-crank to freeze to the pole, so it was discarded and a piece of ordinary wire shown at, D, in Fig. 2 was used instead. The wire, which was about three feet long was attached almost to the top of the pole which had been extended above the whistle valve. The wire was placed at an angle of about 45 deg. and its lower end was located about 3 ft. from and a few inches above the whistle lever and the pulling cord, C, attached as shown.

With this arrangement, the whistle acted promptly but sometimes it closed too slowly after the pull cord was released. To remedy this, a 3-lb. weight, E, was attached to the lower end of the whistle lever.

Indianapolis, Ind. JAMES F. HOBART.

Soft Metal Hammer

THE ARTICLE on this subject by Chas. A. Peterson, on page 1126 of the October 1 issue, reminds me of soft metal hammers which I have made and used successfully for the same purposes as described. Instead, however,



HAMMER MADE OF PIPE FITTINGS WEIGHED WITH LEAD

of removing the pipe fitting mold, I used the fittings and all as a part of the hammer, as shown in the accompanying sketch; and instead of using a wire handle, I used a half-inch pipe for a handle as shown and in molding the hammer, I simply wrapped paper around the rim to form the face of the hammer and to keep the lead from spilling over when the metal was poured.

It is not necessary to fill the tee full of molten lead, the tee may be largely filled with pieces of scrap metal before the lead is poured. This makes an excellent hammer which can be made in almost any desired weight because there are so many standard sizes of pipe fittings. As soon as the babbit faces are worn off, simply throw the whole hammer into a melting pot, melt out the babbit and repour it. It takes only a few minutes to repair the hammer.

Newark, N. J. W. F. SCHAPHORST.

Magnetic Clutch Failure

ONE OF OUR magnetic clutches failed to transmit its designed power transmitting capacity of 600 hp. at 600 r.p.m. At light loads, the clutch acted normally but at ¾ loads and above, severe slipping occurred. The windings were tested and were found free from any fault. The free side of the clutch was dismantled, the live side of the clutch was magnetized and the magnetic flux was tested at different points on the clutch face. This showed that the magnetic pull varied considerably around the face.

After dismantling the clutch, the pole faces were painted with red lead and placed in contact with one another. The marking thus obtained, showed the gap to be much greater on one half of the circumference than on the other. This reduction in effective surface had been sufficient to account for the clutch slipping on heavy loads. After the gap had been equalized by suitably machining the recesses into which the pole faces fitted, the operation of the clutch was satisfactory.

Herts, England. W. E. WARNER.

Duplex Pumps in Elevator Service

IN AN OFFICE building using hydraulic elevators, the night engineer was puzzled by the erratic behavior of the duplex outside-packed plunger pumps, as traffic picked up toward morning.

Elevators operated at about 750 lb. per sq. in. pressure, which was maintained by a weighted vertical plunger in a massive cylinder sunk in the ground beneath the engine room, the pumps feeding into this cylinder.

During the 5 hr. after midnight, the elevator load was light and pumps moved sluggishly or perhaps not at all for periods of 5 min. or more. As daylight approached and load increased, speeding up of the pumps would be attended by terrific pounding like water hammers.

Evidently, the slamming was due to air in the pump cylinders but getting rid of this through the cylinder drain cocks was a slow process and the noise would continue, with lessening intensity for over an hour.

It took quite a time to figure out how air got into the cylinders but the engineer concluded that packing around the plungers became slack while the pumps were standing still or dawdling along and let air filter in to take the place of water leaking out. Renewing the packing before it became too much worn and pulling the glands up snug when the period of low load came on, cured the trouble.

One morning, shortly after heavy load came on, a spasmodic slam developed gradually in one of the pumps. Naturally, the engineer again laid it to air in the cylinder. But test of the air cocks showed his surmise to be wrong.

Taking down the offending pump, the follower plate on one of the steam pistons was found loose. It had been secured by two nuts, the lock nut being drilled and tapped for a set screw to prevent its backing off. That set screw was missing. Somebody had taken it out when the pump was down for repairs and neglected to replace it; so the nuts backed off until the plate had ½ in. or so play.

This points the necessity of making lock nuts fast, where they are subject to vibration, either with a set screw or a cotter pin put through a hole in the nut and a groove or hole in the rod or bolt.

These pumps gave trouble from worn valve-stem pins which gave the valves so much lost motion as to interfere with prompt reversal of the pistons. Also, excessive wear between the contact ends of the rocker arms and the spools on the piston rod had the effect of shortening valve travel and cramping port openings. This caused wiredrawing of steam during admission and slowed down pump action. New parts or wear plates were needed to put pep into the pumps.

Often spools on the piston rods of duplex pumps are held by a single set screw, a rather flimsy fastening that

may work loose and allow the spool to shift to a wrong position so that the pump goes lame or balks entirely. A better fastening is tapered pins driven through holes in the spools and rod.

Gib-end keys, used to fasten the rocker arms to rock shafts, should be secured by set screws, especially for pumps in elevator service. One noon, while traffic was at a peak and the engineer was attending to something in the boiler room, the oiler rushed in with news that the elevator pump had stopped and accumulator pressure was down to zero.

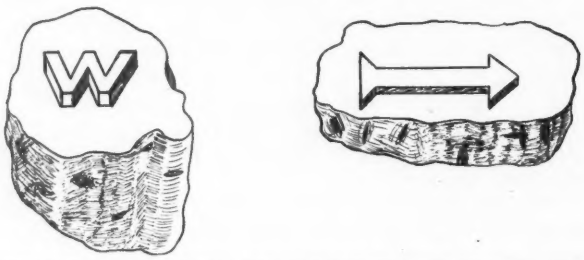
First thought was that the automatic throttle valve of rotating disc type had stuck closed but examination showed it to be open. It took that worried operating man 5 min. to discover that the key had slipped out of one of the pump rocker arms. After that, as soon as opportunity offered, he drilled and tapped the bosses on the rocker arms for ¼-in. cup-pointed set screws. No more slipping keys for him.

St. Louis, Mo. A. J. DIXON.

Quickly Made Large Stamp

PERHAPS SOME persons will get a laugh out of this idea but believe it or not, it proved handy on many occasions right in the old plant for quickly and neatly numbering or lettering.

Sketch shows how to make a very useful stamp for temporary use in ink or thin paint. Just carve it out



POTATOES MAKE GOOD TEMPORARY STAMPS WHICH ARE EASILY MADE

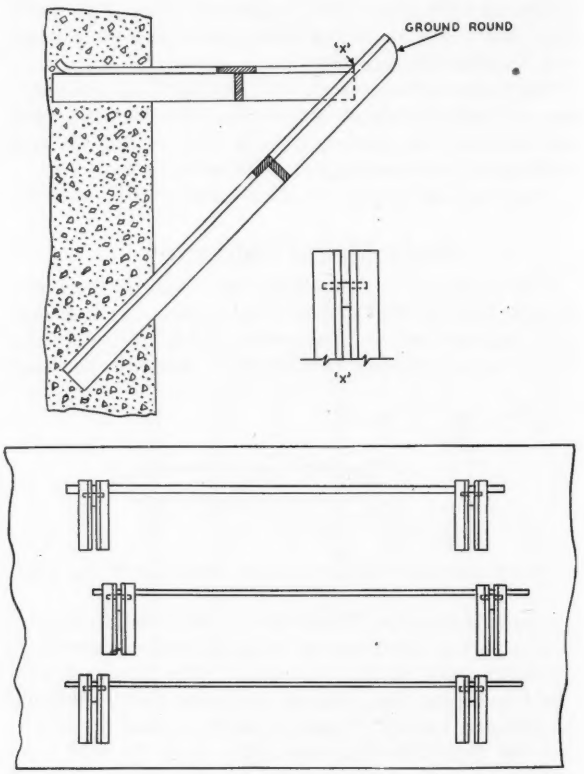
on the surface of a potato. It works well on canvas, burlap, wood or metal. I found it useful to letter quickly the covering on some pipes in a passage from one part of the plant to other buildings, using S for steam, W for water, A for air, etc.

Concord, N. H. CHAS. H. WILLEY.

Pipe Racks of Scrap-Steel Sections

WHEN BUILDING a new store room, we made some changes in the pipe racks that have been satisfactory. They were made out of some old scrap angles and tee sections and so were inexpensive. The simple method of constructing or rather welding them is shown in the sketch. The horizontal section is a piece of 4 by 4-in. tee and the diagonal support is a piece of 3 by 3-in. angle. Any sections can be used; we used these particular ones because we had them handy. The tee section is welded to the angle at the point marked x. This makes a good joint but if the load were to be heavy it might be well to use two angles for the diagonal supports backing them up to each other with the stem of the tee section between them and with the angles tack welded in a number of places so that they would act as a single member.

After welding, the forms were built around the ends and the wall poured with them in place so that a permanent job was secured. We have three tiers, 2 ft. apart so that this gives us three shelves; one is just about even with a man's head. We place only small pipe on the top shelf. It is dangerous to have pipe racks above



SCRAP ANGLES AND TEE SECTIONS MAKE SIMPLE AND CONVENIENT PIPE RACK

a man's head and this always should be avoided. Pipe is a treacherous thing to handle and it should never be necessary for a workman to reach up above his head for it.

Springfield, Ohio. F. PAUL.

Defective Seals Cause Turbine Vibration

VIBRATION of a turbine was caused recently through steam leakage between the shaft and the rotating element of the seal. The leaking steam was not uniformly distributed around the shaft, thus causing it to heat unequally around its circumference and setting up sufficient unbalance to cause vibration resulting in rubbing of the seal which made renewal necessary.

Grooves were cut on the inner circumference of the new seal which was fitted to the turbine thus distributing the steam uniformly around the shaft if any leak occurred, therefore, avoiding unequal heating and distortion.

Herts, England. W. E. WARNER.

Questions and Answers

Action of Three-Valve Steam Trap

WILL YOU PLEASE explain fully how the steam-inlet and air-inlet valves operate on a Bundy three-valve type of steam trap? J. C.

This trap has a fixed discharge valve actuated by the movement of the bowl. When the bowl fills with water it settles down in the circular piece shown, thus opening the discharge valve and the steam-operating valve at the same time. When the water is discharged, the bowl returns to its original position and closes both the discharge and steam-operating valves and opens the vent valve.

THREE-VALVE STEAM TRAP SHOWING ARRANGEMENT OF VALVES AND CONNECTIONS

Gas Flow Through Orifice Meter

WHAT IS THE method of computing the flow of gas through a meter orifice under the following conditions? Pipe diameter, 19¼ in.; orifice diameter, 10.6 in.; gas pressure 25 in. of water, temperature 80 deg. F., specified gravity 0.38.

A. Assuming that you wish fundamental formulas, the one given in the report of the A.S.M.E. Committee on Fluid Meters, third edition, 1931, eq. 14, p. 22 is as follows:

$$V_s = CM \sqrt{2gh\ (w_o - w_b)}\ w \div w_s$$

in which V_s is cubic feet per minute at standard conditions, 30 in. barometer and 60 deg. F.; C is the coefficient of flow, from experiment; M is the meter constant = $A_1 \div \sqrt{(D_1 \div D_2)^4 - 1}$; w is the pounds per cubic foot, the subscripts denoting, o for water, b for air, s for gas at 30 in. and 60 deg. F.; h is difference in pressure across the orifice in ft. of water; A_1 is area of pipe across section, sq. ft.; D_1 is pipe diameter; D_2 is orifice diameter.

Determining values: C as shown for a 12-in. pipe with pressure taps 1 to 2 diameters above the orifice and very close to orifice is 0.607.

To determine M; A_1 for 19¼ in. is 2.02 sq. ft., D_1 is 19¼ and D_2 is 10.6 in., hence $D_1 \div D_2$ is 1.815 and the value of M is 0.6505.

Gas pressure of 25 in. water = 25 ÷ 13.6 = 1.84 in. of mercury, hence absolute pressure is 30 + 1.84 = 31.84 in.

Weight of air per cubic foot for standard conditions is 0.0763 lb., hence, for the gas weight is 0.0763 × 0.38 = 0.029 lb. per cubic foot, which is the value of w_s.

As w varies directly with absolute pressure and inversely with absolute temperature, at temperature of 80 deg. F., which is 80 + 460 = 540 deg. absolute, while 60 deg. is 520 deg.

$w = 0.029 \times (31.84 \div 30) \times (520 \div 540) = 0.0296$ lb. per cu. ft.

For water in the U gage, w_o is 62,376 and for air w_b = 0.0763, hence $w_o - w_b = 62.30$.

2g is 64.32.

Substituting values in the equation for V_s gives: $V_s = 0.607 \times 0.6505 \times \sqrt{64.32 \times h \times 62.3 \times 0.0296} \div 0.029 = 148.2 \sqrt{h}$ cu. ft., per min.

For cubic feet per hour,

$$V_{s\ hr} = 3600 \times 148.2 \sqrt{h} = 533{,}000 \sqrt{h}$$

As pressure drop across the orifice is usually measured in inches of water, while h in the equations above is in feet of water, if H be the drop in inches,

$V_{s\ hr} = 533{,}000 \sqrt{H \div 12} = 533{,}000 \sqrt{H} \div \sqrt{12} = 153{,}700 \sqrt{H}$ cu. ft. per hour.

For the case given, drop through the orifice is so small that no correction is needed for expansibility or change of density of the gas, as would be the case if a small orifice were used.

An important correction, however, is for the presence of vapor in the gas. If saturation is 100 per cent, the correction will be about 3½ per cent to reduce to the actual quantity of dry gas flowing or about 2 per cent to get the actual quantity of saturated gas at 30 in. and 60 deg. If more accurate correction is needed, the method can be found in papers presented by the writer before the American Gas Institute.

With these relations established for a particular case, all that is necessary is to read H, the differential pressure in inches of water and multiply its square root by the established constant.

J. M. SPITZGLASS,
Republic Flow Meters Co.

Editorial Comment

Outdoor Power Stations

When the subject of outdoor power stations is mentioned, most engineers laugh somewhat derisively and remark, "Well, I wouldn't want to operate one," or "They don't save as much by eliminating a building as they think they do." Yet we are surprised to find that the men who scoff the loudest at the idea of outdoor equipment do not know how many of these plants are operating successfully.

Several important hydroelectric projects, such as Norwood, Merced and Osage are known. But, when the idea of operating steam equipment outdoors is suggested, the scoffing grows louder and the scoffers are usually astonished to learn that two outdoor steam plants of major importance are now being designed. One of them is a 1400-lb. plant to be built in California by San Joaquin Light & Power Co. The other is the new mercury vapor plant to be built at Schenectady, N. Y., to serve the General Electric Co. with steam and power and to connect with transmission lines of the New York Power & Light Co.

In Europe, a Benson boiler installation is being operated outdoors with no difficulty reported due to absence of a building. Several years ago when the Ford Motor Co. was building a new power plant at Iron Mountain, Mich., it was necessary to get steam to the factory before the power plant building could be completed and, for several weeks, two boilers were operated with no building around them. No difficulty was reported in operating nor damage to the equipment, in spite of frequent snowfalls and extremely cold weather.

By no stretch of the imagination can the climate at Schenectady be considered tropical. Hence the hoots of derision from engineers when we tell them that the new mercury vapor plant is to be out-of-doors. The reason for the derision is that the engineer usually visualizes an outdoor steam plant as being just like any other steam plant, except that walls and roof will be omitted. He thinks of the inconvenience to the operators of standing before the boiler operating panels in a blinding snowstorm, like locomotive engineers. He forgets entirely that, when the building is omitted, some of the details of the arrangement can be changed so that the operators can be entirely protected by a control room from which all operations can be governed, with only an occasional inspection trip around the equipment. Modern control equipment has been developed to such a high degree of perfection that, when properly designed and installed, centralized control is entirely possible, as exemplified by South Amboy, Bremo Bluff and several other important plants.

In short, it would appear that the steam plant designer of the future will do well to investigate carefully the possible savings in investment in a given plant design that might be made by installing some or all of the equipment outdoors. It seems wise, however, to withhold the derisive laughter until after the investigation, because the investigator might find a way to make a most interesting saving by omitting a building, thus proving that the laughter was somewhat ill-timed.

Human Beings Are Still Useful

In this day of machines, it is consoling to hear that not all machines are perfect. In fact, it is doubtful if robots or mechanical men are as consistently perfect as newspaper reports would sometime lead us to believe. We learn that supervisory robots or foremen are necessary to check upon the work of the machine and these supervisory robots need another supervisor so that the human being is still an essential part of our industrial mechanism.

Recently, an interesting application of a supervisory robot was made, in order to detect and correct the mistakes of an automatic machine. This machine, wrapping waxed paper around packages of cereals, developed a tendency to let the paper slip a little as it went through the feeding rolls. The slipping, repeated with each operation, threw the paper more and more out of register until after a short time the printed trade insignia of the wrapper was out of position on the carton.

The supervisory robot, installed to check up on the wrapping, machinery, functions through an electric eye. Small black spots, in register with the design and uniformly spaced, are printed on the waxed paper. A concentrated beam of light shines through the paper as it feeds into the rollers. The little black spots as they pass, cast shadows upon the sensitive photoelectric tube, causing electrical impulses to be transmitted instantly to one or the other of two relays, which at regular intervals, correct the rate of speed at which the paper passes through the rollers.

Checked up in this manner, the wrapping machine does accurate work within the desired margin of one-sixteenth of an inch, at the rate of seventy-two wrapped cartons per minute, as long as the sleepless electric eye is kept open by another supervisor who must be a human being with the capacity to think and act. Machines may crowd in on human labor but they can never entirely displace the intelligent human being.

Spring Styles

Perhaps you are one of those who have received a seed and bulb catalog with illustrations showing how your yard would look when the flowers are in bloom. Most of us think of the beauty created by flowers as appropriate only to the home or places where pleasure only is the predominant thought and aim. A phase of employment which many executives overlook is the contentment which comes with a pleasant environment for employes. Industrial establishments that employ women workers have been the first to recognize the value of dolling up the grounds with shrubbery and flowers and placing boquets of cut flowers around the factory as a

touch of beauty in otherwise drab and monotonous surroundings.

Men also tire of monotony and lose interest in their work, if progress for themselves and the things with which they are associated is too slow for their temperament. In power plants especially, work for the operators becomes routine, with little variety except when marked additions or changes are made. Most of the workmen are confined within the building walls eight or more hours a day and, under years of such service are likely to develop a complex detrimental not only to their own mental wellbeing but reflected harmfully in the morale of the organization, particularly among the younger and inexperienced members.

Those who have taken the trouble to beautify their surroundings are enthusiastic over the results secured, having accomplished desirable things which were unexpected. Landscaping for power plant grounds is still in its infancy but there are a number of fine examples throughout the country and, with the judicious use of flood lights, delightful color effects can be secured.

With the advent of spring, comes the time to plan flower gardens and shrubbery arrangement to relieve the barren aspect of the plant surroundings. Nature sets the styles for spring and most of us are happy to follow.

Prospecting for Leaders

Old-time prospectors roamed the hills of the west looking for likely looking streams and gravel beds in search of the elusive gold dust and the rarer nuggets. When a promising place was found, the gold pan went into service to separate the gold from the earthy matter.

Similarly, industrial executives of today are continually searching for likely looking human nuggets, exceptional men who can be developed into industrial leaders for tomorrow. Today's leaders of industry must be replaced sooner or later. The young men of today must gradually take the place of our present leaders as the latter, one by one, step out of the picture.

Tomorrow's executive may today be running a lathe, firing a boiler, overhauling an engine or checking material. The hunt for ability and initiative is similar to the old prospector's hunt for gold. Potential managers and executives are scattered throughout the personnel of our industrial plants but the difficulty is to find these hidden nuggets.

Although American industry has made rapid strides in the last generation or two, it cannot sit back in smug contentment, satisfied with the accomplishment. Rivalry among the nations of the world is keen and in order to retain our leadership it is necessary that alert minds be found to carry on. This cannot be accomplished by men who are content with the idea that present methods and materials are good enough. Industry cannot run itself but must have intelligent, alert leadership. Difficult problems will continually rise and will require keen minds with real ability, clear thinking, foresight and initiative.

Future managers and leaders working today in our industrial plants are developing these qualities. Whether in overalls or pushing a pencil, the worker who is to prove a nugget must develop more than ordinary ability and brains. He must stand out as a probable leader of tomorrow. This prospecting is interesting and when successful brings good returns to the seeker as well as the sought.

"Thar's Gold in Them Thar Hills," but nuggets are neither formed nor found in a day. The nugget is the result of long accumulation of valuable material. The finding is by alert watchfulness of all material that comes into view.

Multiple Effect Compressors

In any manufacturing plant, the most important unit is the part that actually produces the product. This is also true of the ice plant although unfortunately the ice tank where the ice is made does not always receive the attention that it deserves. It is here that the profit or loss is made.

Some believe that the ice tank should take water at ordinary atmospheric temperature and freeze it into ice. Others believe that the tank should receive precooled water which is within a few degrees of the freezing temperature. Both schools are well supported by test and operating data so that it is hard to say definitely which is the better or more economical.

In a plant precooling the water, approximately 25 per cent of the total tonnage is used for precooling. Some of this can be provided by utilizing what might be termed waste tonnage, i.e. snow from the scoring machines and cold water from the can dumpers. The balance of the cooling tonnage must be provided by the compressor and, because of the higher temperature of the water, the precooler suction pressure can be held at a higher level, giving higher compressor efficiency and economy.

Two compressors in the plant, one operating on high and the other on low suction pressure, are theoretically satisfactory but, in the usual plant, the added complication of the second and smaller, less efficient machine eats up the major part of the savings. The multiple or dual-effect compressor meets this situation nicely. Although not new, the widespread acceptance of the multiple effect compressor is comparatively recent and its advantages are still unappreciated by the industry as a whole.

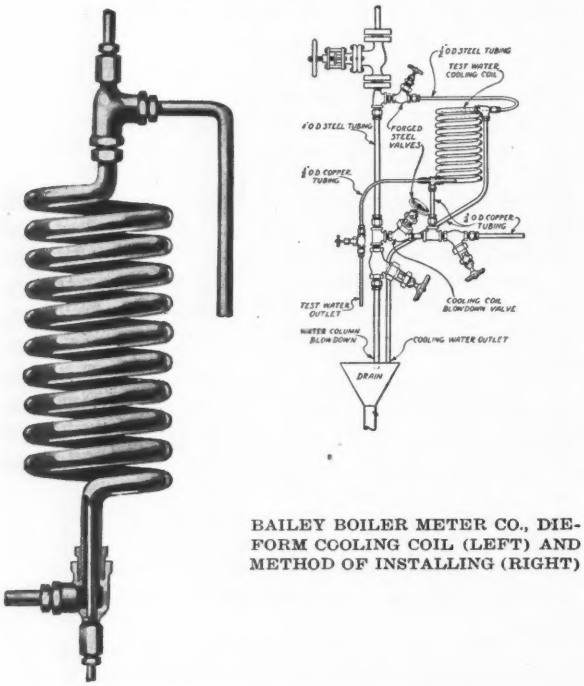
It allows the combined precooler and freezing load to be carried by the one large, efficient machine at practically the theoretical requirements of the two suction pressures. It is no cure-all and requires careful design but, when properly fitted to the plant and properly proportioned, this type of machine will show economies impossible with duplicate compressors. Practical development and acceptance of this type of machine is one of the outstanding accomplishments of the refrigeration industry and should standardize ice tank practice. Surely there can be little argument against precooling now that the multiple effect compressor is available.

CAPACITY, power consumption and wear of pulverizing mills, depend upon the coal used and the so-called grindability index. Tests on one type of mill showed a Logan Co. coal to have a grinding index of about 75 per cent of a Clearfield Co. coal but oddly enough the relative life of its wearing parts was about 50 per cent longer. This relation of wear and grindability does not always hold true; in general, it seems that the harder the coal the greater the wear of parts.

Power Plant Engineering Developments and News

Test Water Cooling Coils

SAMPLING of steam and water at various points in the power cycle has come to be a vital necessity in modern power plant operation. Samples are taken to determine: the quality of water supply; to control the method of treatment for the prevention of corrosion and scale formation; control boiler concentration; minimize wet steam, foaming and priming; detect and measure condenser leakage.



BAILEY BOILER METER CO., DIEFORM COOLING COIL (LEFT) AND METHOD OF INSTALLING (RIGHT)

In order to secure truly representative samples, it is necessary to provide adequate cooling of the hot sample to room temperature while still under pressure. If this is not done, a non-representative sample will be obtained due to flashing of the water samples drawn off. A neat, compact and highly efficient method of securing representative test water samples is now offered by Bailey Meter Co., Cleveland, O., in this Dieform Test Water Cooling Coil. These coils, which consist of a tube within a tube, as shown in the illustration, are made from copper tubing and Dieform compression fittings. In operation, the hot test sample enters the smaller inner tube at the top while the cooling water enters the outer tube at the side outlet on the bottom.

Dieform Test Water Cooling Coils are being used to secure boiler water samples, steam manifold samples, evaporator samples, turbine samples and water samples at boiler feed pumps, feedwater storage tanks and purifiers. The method of installing a Dieform test water cooling coil for obtaining boiler water samples is shown the illustration. It will be noted that the inner tube of the coil is connected to the boiler water column blowdown so that samples of test water may be taken from the blowdown line and cooled to room temperature before they are released to atmospheric pressure. Samples taken in this manner may be collected in glass bottles at the test water outlet. A valve in the cooling water supply line makes it possible to vary the flow of cooling water through the coil and thereby control the temperature of the test water sample. The rate of flow of test water is controlled by a forged steel valve in the ½-in. O.D. steel tubing which connects the test water cooling coil to the water column blowdown.

Most successful results are obtained by drawing test water samples at the rate of approximately one quart a minute and by taking a total sample of approximately one gallon. Dieform test water cooling coils are designed for working pressures up to 1500 lb. per sq. in. and may be built specially for higher pressures if desired.

Heating Boiler Test with Western Coals

RESULTS OF TESTS at the Midwest Power Exposition, made by the Commercial Testing and Engineering Co., on a 70-hp. Kewanee boiler equipped with Whiting Model C stoker which fed Illinois and Indiana coals, are now available and show interesting

TEST PANEL AND ARRANGEMENT OF PLANT

efficiencies as well as the practicability of using low-priced western coals in low-pressure heating plants when proper equipment is provided and given adequate operating attention. Regular records were kept of fuel, draft, pressure, temperatures, air supply and steam flow by an instrument equipment described in the report of the Power Show, Mar. 1st issue, pp. 328-9.

In all, five tests were run, with different coal each time, all being of the classification of screenings. The fuel characteristics were graduated between the extremes of the two for which test results are given and performances varied about as fuel characteristics. As the boiler was new and clean when the first test was run, efficiencies for comparison were reduced to a basis of the same flue gas temperature as for the first test and ran 78.11, 76.7, 76.1, 73.7 and 71.4 per cent.

The two extremes of fuels were Franklin Co., Ill., 1½-in. screenings and St. Clair Co., Ill. Innergroup screenings as follows:

	Franklin	St. Clair
	Per cent as Fired	
Moisture	8.00	9.77
Ash	9.32	15.81
Volatile	32.52	36.43
Fixed carbon	50.16	37.99
Sulphur	1.58	3.83
B.t.u.	12,025	10,629
Ash fusion, deg. F	2140	2080
Combus. in ash	13.25	18.05

Tests were run for 8 hr. at 6 lb. gage, with results as follows:

	Franklin	St. Clair
Feedwater, deg. F	43	42
Flue gas, deg. F	500	532
Over-fire draft in. water	0.03	0.04
Damper draft in. water	0.09	0.10
CO_2 per cent	13.00	11.20
Lb. coal per hr.	429	449
Lb. steam per hr.	3514	2801
Factor of evaporation	1.182	1.182
Lb. steam per hr. from and at 212 deg.	4153	3311
Per cent rating	171.8	137.1
Eff. plant, per cent	78.11	67.4
Eff. plant at 500 deg. flue gas temp.	78.11	71.4
Steam cost per 1000 lb., cts. (coal at $1 per ton)	5.16	6.77

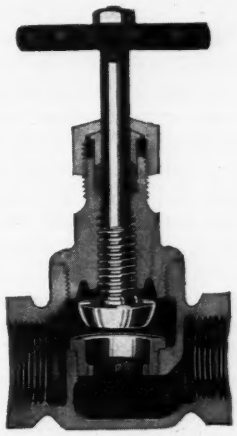
New Valve Uses Renewable Plate

BODIES AND BONNETS of the new Replate valves of the Central Valve Mfg. Co., 231 East 95th St., Chicago, Ill., are cast from special valve bronze, the stem being made from cold drawn bronze. The head of the stem is capped with a removable cold rolled nickel alloy plate, formed to make a ball joint with the seat, the plate being fully supported by the head of the stem. These plates cost but a few cents and can be replaced quickly by unskilled labor, without removing the valve from the pipe line.

An unusual feature in this assembly is in the adaptability of the head of the stem to function without a plate in an emergency, thus maintaining service when an extra plate is unavailable. The nickel alloy seat can be renewed or refaced if necessary.

Repacking may be done safely under pressure in wide open as well as closed position, as a complete joint is formed between the bonnet and the head of the stem when wide open. The possibility of a mechanical failure of the head assembly is removed by the elimination of a screwed connection at that point, the head being riveted to the end of the stem.

The patented construction of the head permits the use of an unusually short stem and bonnet, giving added ruggedness and reducing to a minimum the space required for installation or operation. In addition, a large dead air space in the bonnet prevents rapid transmission of heat from the body to the handle. They are built in sizes from ¼ to 2½ in. for working pressure to 150 lb. per sq. in. and temperatures to 500 deg. F.

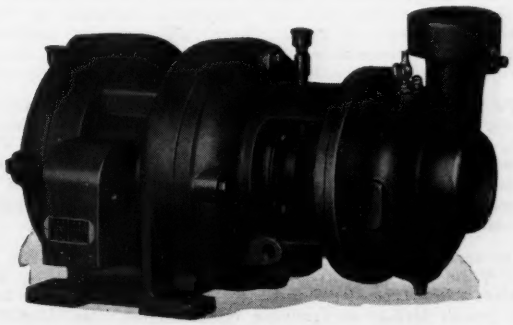


SECTIONAL VIEW OF THE CENTRAL VALVE MFG. CO. REPLATE VALVE

Type SSU Pumping Units

EXTENSION to cover three new sizes in its line of SSU centrifugal pumping units of single-shaft, two-bearing design, which now includes ratings from 30 to 500 g.p.m. for heads under 100 ft., is announced by Allis-Chalmers Mfg. Co., Milwaukee, Wis. Recent adoption of total enclosure of motor housings on the pump end of these units and the use of totally enclosed fan-cooled motors, if necessary, is intended to permit their use for severe service conditions.

SSU pumps are designed especially for heads heretofore not adequately covered by a low-price, guaran-



SSU PUMPING UNIT WITH 3500-R.P.M. MOTOR

teed, high-grade pump. Some applications of these pumps are for: water supply; circulation of water, oil or brine for heating or cooling system; for transfer of many liquids; air conditioning; bottle washing and other washing machinery; drainage systems; house service; auxiliary service to power equipment for cooling water seals.

Death of A. F. Botfield

ALFRED BISHTON BOTFIELD died recently in Miami, Florida, at the age of 83. He was born September 20, 1847, at Shifnal, Shropshire, England, and received his education in the schools and universities of that country.

Mr. Botfield was originally a manufacturing jeweler in England and was recognized as one of the finest judges of precious stones on the Continent. While in Cuba in 1899, he acquired a controlling interest in a marine construction and repair enterprise at Havana, which occupied his attention until the United States relinquished direct supervision of Cuban affairs.

Mr. Botfield then came to this country, where he established the Botfield Furnace Specialties Co. in Philadelphia, engaging in the building and repairing of stationary and marine boiler settings. At the start of this century, he began his earliest experiments to develop a mortar which would function as a cement, to bond brick to brick in the same manner as one piece of iron was then being joined to another piece of iron by the process of welding which was a comparative innovation.

In 1907, Mr. Botfield produced the first commercial batch of his new bonding material, and it was used for the bonding of fire brick in boiler settings at the Continental Dye Works in Philadelphia. Evidence of the accuracy of his vision and foresight is the fact that his original batch of a few hundred pounds of high temperature cement was the forerunner of the many thousands of tons of high temperature refractory cement that are produced annually in the United States at the present time.

In 1915, Mr. Botfield retired from active business and the conduct of the Botfield Furnace Specialties Co. was assumed by his son, Leonard Bishton Botfield, who is now president of the succeeding Philadelphia concern with the corporate title of Botfield Refractories Co.

News Notes

THE THERMOID RUBBER CO. of Trenton, N. J., announces that John H. Kelly has joined its staff. Mr. Kelly started with the B. F. Goodrich Co. in 1898 and from there went to the Republic Rubber Co., where he rose to Vice-President in Charge of Sales by 1912. Later he became President of the Hewitt Rubber Co. and when this organization entered the Gutta Percha Rubber Mfg. Co.-Robins Conveying Belt Co. merger, he assumed the Vice-Presidency in Charge of Sales. Since 1928, when Mr. Kelly was forced to retire from active duty due to a serious illness, he has been doing special counselling work.

THE ASHTON VALVE CO., Cambridge, Boston, Mass., announces the election of Henry B. Nickerson as Vice President in charge of sales. Mr. Nickerson until his election as above noted was Vice-President of the Consolidated Ashcroft Hancock Co., and prior thereto with the American Schaeffer & Budenberg Corp. and the American Steam Gage and Valve Manufacturing Co. Mr. Nickerson assumed his new duties March 16.

GENERAL SPRING CORP. has opened offices at 17 East 45th St., New York, for the purpose of marketing the Genspring Pipe Hanger, a new type of spring hanger for steam and oil pipe lines, with Joseph McKay as syndicate representative. Mr. McKay is known in the power plant field, through his former affiliations with the Wheeler Condenser and Engineering Co., Pittsburgh Valve Foundry and Construction Co., Payne Dean Ltd., Cutler-Hammer, Inc., Liberty Electric Corp., M. W. Kellogg Co. and The Limitorque Corp.

CHARLES W. NAYLOR, chief engineer for Marshall Field & Co., Chicago, Ill. and an employe of the firm for 45 yr. died of heart disease Saturday night, March 7, a short time after he had struggled through a violent snow storm to his home from the elevated station a few blocks away.

Mr. Naylor was 72 yr. old; he was born in Leeds, Yorkshire, England and brought to this country as a baby by his parents, who later moved to Chicago. He was graduated at the University of Chicago in 1881. He was a member of Psi Upsilon fraternity and of Garfield Lodge A. F. & A. M., Past National President of the National Association of Power Engineers, member of the American Society of Mechanical Engineers and member of the Western Society of Engineers.

Books and Catalogs

AMBER TO AMPERES, by Ernest Greenwood; 332 pages, 6 by 9 in., illustrated, cloth. Published by Harper and Brothers, 49 East 39th St., New York, 1931; price, $4.00.

As a non-technical or popular history of electricity, this book leaves much to be desired. The author, who obviously is more conversant with the phantasies and imageries of classical mythology than he is with the facts and fundamentals of electricity, in a rather futile attempt to impart an artificial romance to a subject inherently replete with romance, has succeeded only in presenting a curious mixture of Greek and middle-aged European history and a smattering of electrical facts. The material was first published as a series of articles in the N.E.L.A. bulletin.

Apparently the author's purpose was to present a social, economic history of electricity from its earliest discovery by Thales to its present development, written for the layman and woven around the outstanding contributors and contributions in each era throughout 35 centuries. Though such facts as he presents are accurate, it is evident that his knowledge of the subject is haphazard. His attempt to portray the social conditions of the day surrounding the various individuals considered adds little to the value of the book and in a field which itself contains so much human interest, detracts from, rather than enhances the interest of the narrative. These things aside from the fact that the book lacks continuity perhaps are the least to be criticized, for, after all, they are to a certain extent matters of personal opinion and that which may appeal to one may not appeal to another.

But what are we to think of a book which purports to be a popular history of electricity in which Steinmetz is scarcely mentioned and which omits any reference to Elmer Sperry and Elihu Thomson, the latter with more than 700 patents to his name, most of them electrical, the third largest number held by any one man? How are we to regard a book in which not a word appears about Sir J. J. Thomson, to whom more than any one else goes the credit for the discovery of the electron, the fundamental unit upon which the whole modern science of electricity rests? Again, how are we to judge a book in which no mention is made of Dr. Milliken, who determined the charge of the electron and determined its mass by an experiment so beautiful, so precise and so far reaching in its importance that it remains the outstanding classic experiment of modern electronics? No mention of this experiment is made in Mr. Greenwood's book.

It seems inconceivable that any one could write a book on electricity and not mention these men and their work, yet this is exactly what Mr. Greenwood has succeeded in doing and much more in addition.

In presenting the history of the incandescent lamp, for instance, practically no mention is made of Langmuir or Coolidge, to whose genius the modern incandescent lamp is due. The work of Edison, to be sure, is treated at great length. The author goes out of his way to defend Edison's claims but nothing is said of the Edison effect which lies at the bottom of the whole vacuum tube industry, indeed at the foundation of the whole modern radio industry itself.

The whole marvelous story of the development of radio is disposed of in a brief chapter which is given over more to a discussion of the commercial activities of the Radio Corporation and the Federal Radio Commission than it is to the painstaking work of those scientists whose love of the art gradually made radio what it is today. It omits all mention of the part played by the radio amateur who, with inexpensive home-built equipment and under terrific handicaps imposed upon him by commercial interests, showed these same interests how to encircle the globe with short waves. The romance of this subject is lost entirely. Indeed, for the best description of radio, the author quotes one by a graduate of the *school of business administration* of Harvard University!

In that section of the book which deals with the telephone, only the early work of Bell is given any consideration. All researches of the American Telephone and Telegraph Co. seem to have been passed over. Michael Pupin, whose mathematical solution to the problem of long distance telephony and its resulting development of the loading coil made transcontinental telephony possible, is not even listed in the index nor is any mention of his work made. Oliver Heaviside in the same connection also receives no mention.

As already stated, scarcely a word appears regarding Chas. Proteus Steinmetz, that mathematical genius who, two years after he arrived in America a poor deformed cripple, stood up before the American Institute of Electrical Engineers and delivered a paper which, for the first time, gave the electrical engineer a method of dealing mathematically with alternating current functions. The name of Steinmetz is mentioned, true enough, but only incidentally. Nothing is said of his long line of later achievements or of the General Electric Co.'s high esteem for him.

And in connection with the General Electric Co., the largest electrical manufacturing company in the world, it may be pointed out that in this book which purports to be the story of electricity, not the briefest reference is made to Chas. Coffin, the Lynn, Mass., shoe manufacturer who founded the General Electric Co. and whose confidence in scientific method led to the establishment of the research laboratory which has paid so richly in achievement.

Geo. Westinghouse, whose dynamic force is crystallized in the great electrical manufacturing company which bears his name today, is mentioned in a single paragraph on page 159 in which, aside from a brief reference to the introduction of the transformer which is at the base of our entire electrical transmission system, no inkling is given of the importance of Geo. Westinghouse's efforts in the development of alternating current machinery and distribution.

Of course, it may be argued that these achievements of Milliken, Langmur, Steinmetz, Coffin, Westinghouse, etc., and the General Electric, Westinghouse and A. T. & T. Companies are all recent when compared to the history of electricity since Thales' day and that in the many centuries preceding the 20th, the electric art was growing steadily and that these achievements are only the flowering of a plant which received long cultivation. This is true enough and for this reason the object of devoting a large part of the book to the work of the early investigators is an admirable one but in this the author seems to have succeeded poorly. Much of the material presented in this section is irrelevant and applies more to a history of philosophic and economic thought than it does to one of electricity.

Compared to similar books on other branches of science, this book makes a poor showing. The reason is very evident: a decided lack of knowledge of the subject. Creative Chemistry, by Slosson, was a success, not only because Slosson was a clever writer but because he was a trained chemist. He had the knack of expressing highly technical material in a language such as the layman could understand. The same applied to Microbe Hunters. Paul De Kreiff who wrote it was a bacteriologist of distinction long before he became an author.

We have no record of Mr. Greenwood's qualifications for writing a book of this type other than that he is 47 yr. old, a graduate of Cornell University and that he has been an official of the League of Nations. He has been a vice president of the District of Columbia Board of Education and is said to be an expert on international relations. He has been decorated by the French Government.

HYDRAULIC TURBINE GOVERNORS and Frequency Control are discussed in publication No. 13 just issued by the Hydraulic Power Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City.

This report considers:

(1) Those fundamental principles underlying the design and operation of the hydraulic governor which may influence the application and operation of any method of frequency control; (2) the question of frequency control as developed to date; (3) the economical distribution of load on various units of a system; (4) the regulation of impulse wheels and the application of frequency control thereto; (5) instability of hydroelectric units as related to the governor; (6) hydraulic units without governors; (7) recent developments in hydraulic governor design; and (8) maintenance of the governor.

List of definitions of important terms is presented, manufacturers' statements on hydraulic governors and on automatic frequency and load control equipment are included and in addition bibliography of articles on the subjects of hydraulic turbine governors and frequency control is contained herein.

PUBLICATION of a folder containing specific design data for corrosion resisting and heat resisting alloys has just been announced by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. This contains a precise up-to-date statement of the fabricating, mechanical, physical and chemical properties of all the commercially-available metallic alloys required by engineers, chemists and other technicians in the design of equipment for modern processes. The A.S.T.M. has also issued report on Committee C-10 on hollow masonry building units, and report of Committee A-1 on Steel.

A NEW CATALOG, No. 903, describing the construction and application of the Fuller-Kinyon System to the transportation and distribution of pulverized coal, has just been issued by the Fuller Lehigh Co., 85 Liberty St., New York, N. Y. Besides including a general description and a diagrammatic sketch of the System, the catalog contains a number of illustrations of the equipment and views of installations.

A NEW 12-PAGE, illustrated circular, covering Dry-Type Transformers and Autotransformers, is announced by the Westinghouse Electric & Manufacturing Co. This booklet, which is identified as Circular 1886, contains, in addition to descriptions of the application, operation and construction of the various transformers, tables giving their ratings, style numbers, weights, and dimensions. Because of their small size, these transformers are especially applicable where space limitations or insurance regulations prohibit the use of oil-insulated apparatus.

FOLDER D.M.F. 5299 covering the use of steam jet air ejectors in industries using vacuum processes has just been issued by the Westinghouse Elec. & Mfg. Co. Among the several types of air ejectors discussed are: two-stage condensing types with either surface type intermediate and after condensers or jet type intermediate condensers only; single-stage condensing or non-condensing ejectors; and compound ejectors on jet intermediate and after condensers.

SECOND ANNUAL DIRECTORY of American Aircraft Engines has just been issued by the International Nickel Co., Inc., 67 Wall St., New York City. This shows the extent to which alloy steels in general and nickel alloy steel in particular are contributing to the progress of aeronautics. Eleven more engines are included in the 1931 directory than in last year's directory. The new issue describes four two-cylinder engines that were not in last year's issue. A preface to the directory points out that the important developments in materials of construction which have helped to make the airplane of 1931 a safe and dependable machine are all too often disregarded.

ROCK WOOL, a material developed for use as industrial insulation in refineries, heat treating equipment, cold storage work, and so on, in addition to power plant work, is described in detail in bulletin No. 100 just issued by General Insulating & Mfg. Co., Alexandria, Ind. The bulletin discusses the production of Rock Wool blown from a fused natural stone, shows the various grades and mechanical, thermal and other characteristics. In bulletin No. 200, the company describes the use of this material for pipe insulations, in bulletin No. 340 its use for sound insulation and, in No. 400, Flexfelt. Details of application of the material are given. All these bulletins are bound in loose-leaf form in an attractive cover.

NUGENT OIL FILTERS of the gravity type, their construction, operation and application, are described in bulletin No. 7 just issued by Wm. W. Nugent & Co., 410 N. Hermitage Ave., Chicago, Ill. The bulletin discusses such items as the automatic continuous oiling and filtering system, portable motor driven continuous flow oil filter, the automatic dirty-filter alarm and other features. Every detail of the filters is illustrated and described. There are tables of dimensions and engineering data and many photographs showing application of the filters.

A-JACKS CONTROL for high-pressure boilers is discussed in a new bulletin No. 34G, published by National Regulator Co., 2301 Knox Ave., Chicago, Ill. Description is first given of the A-Jacks steam damper regulator with phantom photographs to show its interior construction. Then the bulletin takes up the new A-Jacks over-fire control and concludes with a discussion of A-Jacks installations to show how the regulators are applied to perform various operations on modern high pressure boilers, with charts showing results obtained with them.

FULTON GAS REGULATORS with automatic cutoff for natural gas and the Fulton Duplex Sensitive Gas Governor for manufactured gas are described and illustrated in detail in a new 72-page bulletin just issued by the Chaplin-Fulton Mfg. Co., 28 Penn Ave., Pittsburgh, Pa.

ALCOA ALUMINUM for truck bodies is discussed in an 80-page, well illustrated bulletin, just issued by Aluminum Company of America, 2400 Oliver Bldg., Pittsburgh, Pa.

ENGELHARD THERMOCOUPLES for temperature measurements are described in a recent bulletin by Charles Engelhard, Inc., 90 Chestnut St., Newark, N. J.

Power Plant Construction News

Ark., Bentonville—The Ward Ice Industry, 201 North Tenth Street, Fort Smith, Ark., contemplates extensions and improvements in cold storage and refrigerating plant of Bentonville Ice & Cold Storage Co., recently acquired.

Ala., Alabama City—Hardwood Products, Inc., Alabama City, is said to be planning installation of electric power equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss close to $50,000.

Calif., Daggett—The Ord Copper Co., Daggett, Victor Smith, manager, plans installation of electric power equipment in a proposed new milling and concentrating plant near Daggett, entire project to cost over $1,000,000. A power house will be built.

Calif., Oakland—The Owen-Illinois Glass Co., 965 Wall Street, Toledo, Ohio, plans installation of electric power equipment in proposed new bottle-manufacturing plant on site now being selected at Oakland, entire project to cost close to $1,000,000. William E. Levis is president and general manager.

Conn., Meriden—The City Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks, for which a bond issue of $80,000, has been authorized. C. P. Prann, City Hall, is city engineer.

Ga., Port Wentworth—The American Atlas Corporation, Port Wentworth, near Savannah, Ga., plans installation of electric power equipment in proposed new rayon weaving mill, entire project to cost over $80,000.

Ga., Savannah—The Smith Lumber Co. is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of lumber mill recently destroyed by fire with loss reported over $100,000.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has filed plans for a three-story addition to service plant at 2201-9 Throop Street, 38x124 ft., to cost about $50,000. Nimmons, Carr & Wright, 333 North Michigan Avenue, Chicago, are architects.

Ill., Rock Island—The City Council has preliminary plans under way for a pumping plant for municipal sewage service and is said to be planning early construction.

Ky., Mount Sterling—The City Council, Mount Sterling, is having a report made by the Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., engineer, for a proposed municipal electric light and power plant. Estimates of cost will soon be made.

La., Shreveport—The Atlas Pipe Line Co., E. R. Ratcliff, president, Shreveport, recently organized, plans installation of pumping plants and other mechanical equipment in connection with a proposed pipe line with capacity of 18,000 barrels from Longview, Tex., field to Shreveport, reported to cost over $650,000, with equipment. J. K. Wadley, Texarkana, Tex., is interested in the new company.

Mo., Cape Girardeau—The Marquette Cement Mfg. Co., Arcade Building, St. Louis, plans extensions and improvements in power plant at cement mill at Cape Girardeau, in connection with a general expansion program. The Burrell Engineering & Construction Co., 1 North Canal Street, Chicago, Ill., is engineer.

Mich., Muskegon—The Muskegon Gas Co., Muskegon, is planning an expansion and improvement program in artificial gas plant and system during 1931, to cost about $100,000. New gas purification equipment, compressor unit and other machinery will be installed in plant.

Minn., Litchfield—The City Council is said to have plans completed for the installation of a new generating unit and auxiliary equipment at the municipal power plant. Estimated cost has not been announced. Louis P. Wolff, Globe Building, St. Paul, Minn., is consulting engineer.

Mont., Butte—The Montana Power Co., Butte, plans installation of a series of compressor plants for booster and operating service in connection with a new pipe line for natural gas service to properties of Anaconda Copper Mining Co., Anaconda, Mont., and other industrial interests, entire project to cost over $8,000,000.

N. Y., Buffalo—The Board of Trustees, University of Buffalo, has filed plans for a steam power plant at the institution for central heating service, estimated to cost $200,000, with equipment.

N. C., Asheville—The Asheville Hosiery Co., Asheville, plans installation of electric power equipment in new two-story mill addition, entire project to cost about $90,000. F. Q. Boyer, Asheville, is architect.

Ohio, Franklin—The City Council, Franklin, has a preliminary report under way for the installation of a municipal electric light and power plant. Estimates of cost will soon be made. Black & Veatch, Mutual Building, Kansas City, Mo., are consulting engineers.

Ont., Thorold—The Ontario Paper Co., Thorold, an interest of the "Chicago Tribune," 435 North Michigan Avenue, Chicago, Ill., plans installation of electric power equipment in connection with an expansion and improvement program at mill, entire project to cost close to $500,000. Arthur A. Schom is general manager at plant.

Ore., Baker—The Stoddard Lumber Co., Baker, is said to be planning installation of motors and other electric power equipment in connection with proposed rebuilding of pine lumber mill, destroyed by fire, March 7, with loss reported in excess of $85,000.

Pa., Philadelphia—The Ajax Metal Co., 46 Richmond Street, plans installation of electric power equipment in new plant addition at Frankford Avenue and Laurel Street, entire project to cost over $100,000. Work will soon begin. M. Ward Easby, 1505 Race Street, is architect.

S. C., Aiken—The City Council is said to be planning an early call for bids for a Diesel oil engine and auxiliary equipment, in connection with extensions and improvements in municipal electric light and power plant. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Texas, Houston—The Houston Oil Refining Co., Houston, plans installation of power equipment in connection with proposed extensions and improvements in oil refining plant to cost close to $300,000.

Texas, Kilgore—The Common Council, Kilgore, is said to be planning installation of pumping machinery and auxiliary equipment, in connection with proposed extensions and improvements in municipal waterworks and sewage systems.

Texas, Lathrop—The Yount-Lee Oil Co., Beaumont, Texas, plans installation of a series of pumping plants and other operating equipment in connection with a proposed new pipe line from Lathrop to Beaumont and vicinity, about 200 mi., entire project to cost over $2,500,000.

Texas, Longview—The Morgan Utilities Co., Inc., has plans for the immediate construction of a one-story ice-manufacturing plant, 75 x 100 ft., on local site, to cost close to $100,000, with machinery.

Texas, Port Arthur—N. J. Hebert, 1748 Sixth Street, Port Arthur, and associates are considering the construction of a one-story ice-manufacturing plant on local site, with capacity of about 25 tons, reported to cost close to $40,000, with equipment.

Texas, Temple—The Common Council, Temple, plans installation of power equipment, construction of reservoir with capacity of 250,000 gals., etc., in connection with extensions and improvements in municipal waterworks, for which a fund of $65,000, has been arranged. City engineer is in charge.

Va., Covington—The Virginia Gas Transmission Corporation, Charlottesville, Va., an interest of the Columbia Gas & Electric Corporation, 61 Broadway, New York, plans construction of a series of compressor plants in connection with proposed new pipe line for natural gas service from Covington to Washington, D. C., entire project to cost close to $5,000,000.

Wis., Oakfield—The Village Council has engaged the McMahon Engineering Co., Menasha, Wis., to prepare plans for proposed municipal water works to cost about $40,000, to include the installation of a pumping plant, elevated steel tank with capacity of 60,000 gals., and other equipment. It is expected to ask bids about April 1. H. W. Warner is village clerk.